The Glasgow Naturalist

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Volume 27 Part 2

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The Glasgow Naturalist

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Front cover Arctic tern (*Sterna paradisaea*) feeding chick, Skálanes, East Iceland, summer 2019. (Photo: Thomas MacGillavry)

Back cover Kylie the short-beaked common dolphin (*Delphinus delphis*), near the Isle of Cumbrae, Firth of Clyde, Scotland. (Photo: Jonas Gaigr)

The Glasgow Naturalist
Volume 27 Part 2

Edited by: Iain C. Wilkie & Christopher J. McInerny

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The Glasgow Naturalist (2020) Volume 27, Part 2, 1-2

EDITORIAL

Unprecedented times

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As we are being reminded on an almost hourly basis, we are currently living in unprecedented times. The coronavirus pandemic has forced the U.K. Government to introduce "lockdown" rules, which include allowing only one form of exercise per day and banning public gatherings of more than two people who do not live together. Vulnerable individuals may have to self-isolate for months. It is fortunate then that natural history is perhaps the one remaining scientific discipline in which solitary individuals can still make a significant contribution to knowledge (though even solitary individuals have their "networks", as ably demonstrated by Charles Darwin's correspondence (Burkhardt & Smith, 1985-2019), and so are never really working alone). As it should be possible to combine one form of exercise per day with natural history observations or investigations, the current situation may even lead to an expansion of interest in, and data on, the natural world.

For those stuck indoors, now could be the time to look out those dust-covered shoe boxes and other containers full of samples that you have never got round to examining. There could be surprises in store, as the article by Monson & Luxton demonstrates in this issue (Monson & Luxton, 2020). Their paper is based on an extensive set of samples collected over 30 years ago, which has yielded 12 species of oribatid mites new to Britain. Of course there may come a time when a naturalist realises that, due to declining interest, stamina or availability of resources, unworked samples will never be attended to and might as well be disposed of. In view of their potential scientific interest, and as long as they are fully labelled with information on habitat, location and date, these should be donated to an appropriate institution. For example, *Glasgow Museums* has a collecting policy, and is always interested in good quality, well labelled collections from Glasgow and the west of Scotland.

Volume 27, Part 2 contains contributions dealing with a broad range of taxa. Three major kingdoms are represented - Animalia, Fungi and Plantae, with 16, one and two articles respectively. The animal articles are dominated by invertebrates (14), including five different phyla, arthropods being on top (10). The invertebrate articles include a number of groups that, though ubiquitous, are not usually encountered by the amateur naturalist - tardigrades (water bears), Thysanoptera (thrips) and oribatid mites, but all of which would benefit from more attention and whose study does not require sophisticated equipment or methodologies. This issue is also geographically adventurous, in that the tardigrade paper (Blagden *et al.*, 2020) refers to both Irish and Scottish sites and the mite paper is an important contribution to the natural history of the Isle of Man (the place-names of the sampling sites being worth reading in themselves, since, despite the differences between Gaelic and Gaelg (Manx) orthography, they are a reminder of the cultural heritage common to that island, Scotland and Ireland). One short note stretches the chronological envelope and takes us back to Neolithic/Bronze Age times when our ancestors, for reasons unknown, left great auk bones in the Covesea Caves of the Moray Firth (Fitzpatrick *et al.*, 2020).

This issue also marks the passing of Dr Ron Dobson, who was Editor of *The Glasgow Naturalist* from 1984 to 1995. Hancock *et al.* (2020) provide a fitting tribute and include a bibliography of Ron's publications. As I mentioned in the editorial for the previous issue, I started helping with the editing of the journal under Ron's leadership. Amongst the changes he introduced was the refreshing of the journal's appearance. At that time it had dark blue covers and the combination of the Glasgow Coat of Arms and the gothic font used for the title gave it a somewhat "municipal" aura. Ron introduced brighter cyan covers, a modern font, and on the front cover a black line drawing based on an illustration from one of each issue's articles, an innovation that has developed over the years into the inspirational colour photographs that now fill the front and back covers. This issue's cover photographs are PhotoSCENE prize winners, the other prize winners being printed inside and showing a taxonomic diversity more in favour of vertebrates than that of the short notes and papers.

The journal now subscribes to the DOI system. A DOI (digital object identifier) is a unique string of numbers and letters that is assigned to an online document. You will see the DOI at the top of each short note and paper in this issue. A DOI can be used in a similar way to a URL, but is more permanent and reliable (it has been likened to a National Insurance Number). The system also interlinks journal articles: sources cited in the lists of references at the end of each short note and paper now include DOIs where these are available. In order to have DOIs assigned to our content, GNHS had to become a member of a DOI Registration Agency, which in our case is *Crossref* based in Massachusetts, U.S.A. *Crossref* sends me monthly reports of the number of times the DOI links for the journal and individual articles are clicked by a user, which provides an indication of the level of interest. In February and March the total number of "clicks" was 150, with most attention being given to the paper on Irish and Scottish tardigrades (35 clicks). The Editorial Committee is hoping that DOIs will help to heighten the profile of the journal and its contents and increase its attractiveness to potential authors. We intend to assign DOIs retrospectively to articles in Vol. 27, Part 1 and in the Vol. 27 Amphibian & Reptile Conference supplementary issue.

It had been our intention to include in Volume 27, Part 2 the second batch of articles in the series *On the Wildside Revisited: 200 Years of Wildlife in the Glasgow Botanic Gardens*. These will be published in Volume 27, Part 3.

ACKNOWLEDGEMENTS

It cannot be repeated often enough that editing *The Glasgow Naturalist* is a team effort and I would like to acknowledge the assistance of Chris McInerny, Ruth Maclachlan and Richard Weddle. I am also grateful to Ruth Maclachlan and Su Futter, GNHS Treasurer, for the extra work they put in during the *Crossref* registration process. The evaluation of submitted manuscripts by external experts is critical for maintaining the journal's scientific standards and all who made such a contribution to this issue are thanked sincerely. The external reviewers for this issue were (in alphabetical order): T.J.C. Beebee, T. Bolger, G.A. Boxshall, F.V. Crotty, M. Culshaw, M. Dobson, E.G. Hancock, C. Hobart, R.K.S. Gray, A. Jackson, W. Kirk, H.A. Meyer, P.G. Moore, M. O'Reilly, N. Redgate, J. Robinson, M.J. Shepherd, R. Sutcliffe, G. Walker and K.J. Watson.

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Note added in proof

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FULL PAPERS

Parasitoid wasps indicate that the marsh fritillary butterfly (*Euphydryas aurinia*) has persisted on Tiree rather than re-colonised recently

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ABSTRACT

The population of the marsh fritillary butterfly (*Euphydryas aurinia*) in western Scotland fluctuates greatly and the species is difficult to locate during periods of scarcity. It was recorded on Tiree in 2014 for the first time in 64 years during a period of abundance. The nearest known populations occur 40 km to the east and its discovery represents either a recent colonisation event well beyond its known capability or it has escaped detection for a longer period. Surveys for the larval cocoons of two wasps that are parasitoids of *E. aurinia* and host-specific were undertaken on Tiree in spring and autumn 2017. The adult wasps are small with limited powers of dispersal and are unlikely to have followed *E. aurinia* to Tiree since 2014. Cocoons of one species - *Cotesia melitaearum* - were abundant in all concentrations of *E. aurinia* in spring 2017 but neither species was found in the autumn. The absence of the second species - *C. bignellii* - is inconclusive as it was also absent at known locations elsewhere in autumn 2017. The occurrence, distribution and abundance of *C. melitaearum* on Tiree indicate that *E. aurinia* had been present for some time before its discovery in 2014. Although continuous presence since 1950 cannot be extrapolated with certainty, the results highlight the propensity of *E. aurinia* to persist for long periods in numbers that fall below the observation threshold, even in areas of high wildlife awareness, and that it is not always an easy species to record.

INTRODUCTION

The marsh fritillary (*Euphydryas aurinia*) is a species of high conservation concern and is protected in the European Union as it is still declining in large parts of the U.K. and Europe. In common with similar species, it is relatively immobile, and fragmentation of its habitat and the isolation of populations are the principal factors in its decline, limiting the re-colonisation of habitat after local extinction (Ehrlich & Hanski, 2004; Schtickzelle *et al*., 2005).

The species fluctuates greatly in abundance from year to year throughout its range, even at sites with apparently ideal habitat that are under recommended management. Although its biology is not understood fully despite its status, two parasitoids that are specific to *E. aurinia* are known to cause high caterpillar mortality in some years.

The western seaboard of Scotland supports one of the principal concentrations of *E. aurinia* in the U.K. Here it is common in coastal Argyll and on the larger Inner Hebrides such as Mull, Islay, Jura and Lismore. Even so, understanding of its status in the region is incomplete. For example, it has been recorded in over 200 new 1 km squares in the last 20 years on Islay. Populations in Scotland utilise more varied habitats than elsewhere in the U.K. and occupy marginal agricultural land that is grazed or abandoned.

The butterfly was recorded on Tiree in 2014 during a period when it was abundant elsewhere in western Scotland. This was the first record on the island since 1950 (NBN Atlas, 2016) and subsequent observations revealed both adults and caterpillars to be widespread (J. Bowler, pers. comm.). Tiree is 30 km west of the nearest land (Mull) that is known to support *E. aurinia,* and 40 km from the nearest known populations on the Ross of Mull and Mishnish. Tiree is a relatively small island (*ca*. 80 km^2) and its fauna and flora, especially its birds, have been recorded intensively (e.g. Bowler & Hunter, 2007; Bowler *et al*., 2008). The appearance of *E. aurinia* presents a puzzle, therefore, as it represents either a recent long-range colonisation event far beyond its known capability or long-term persistence that has escaped observation in an area of high wildlife awareness.

This study in 2017 aimed to establish if the host-specific parasitoids of *E. aurinia* are present on Tiree. These are small braconid wasps with a wingspan of 2-3 mm and typically with more limited powers of dispersal than their hosts (Lei & Hanski, 1998; van Nouhuys & Hanski, 2002) and are unlikely to have tracked the butterfly to Tiree since 2014. Their absence would suggest that colonisation by *E. aurinia* is recent and their presence would confirm longer-term presence of the butterfly.

THE STUDY SPECIES

The marsh fritillary flies mainly in June in Scotland, and its eggs hatch in July. Caterpillars live gregariously and cryptically during the early stages of growth but construct prominent “webs” of silk on the foodplant devil’s-bit scabious (*Succisa pratensis*) towards the end of August, when they are 2nd instars (caterpillars moult between each instar, or stage of growth). Feeding webs of the 3rd instar are visible through to the moult to the 4th instar in September or early October when the caterpillars construct a web deep in the vegetation and hibernate. Caterpillars emerge from hibernation most usually in early-mid March and develop quite slowly to reach the 5th instar in late March or early April. These grow rapidly to reach the final 6th instar in mid-April and pupation by early May (pers. obs.).

Two conspecific parasitoids - *Cotesia melitaearum* and *C. bignellii* - attack *E. aurinia* and are specific to it in Scotland. "*C. melitaearum*" is an aggregate of morphologically identical cryptic species each of which may be specific to one host within the tribe of butterflies (Melitaeini) which includes *E. aurinia* (Kankare & Shaw, 2004; Kankare *et al*., 2005). *Cotesia melitaearum* is widespread but *C. bignellii* was recorded for the first time in 2014, on Islay (pers. obs.). Elsewhere both species have up to three generations per generation of *E. aurinia* (Porter, 1979; Stefanescu *et al*., 2009). Three generations of *C. bignellii* do occur on Islay, but only two of *C. melitaearum* have been recorded so far: a third generation of the latter has yet to be recorded in Scotland (M.R. Shaw, pers. comm.).

The spring generation of both species is evident when one or two wasp larvae emerge from caterpillars of *E. aurinia*, usually when 4th instars moult in late March and early April, and spin cocoons in which to pupate. The cocoons of *C. melitaearum* are relatively easy to spot in or around the feeding and moult webs of 4th instar caterpillars (Fig. 1), but those of *C. bignellii* are difficult to locate as caterpillars harbouring this species may disperse and hide before wasp larvae emerge (pers. obs.).

The adult wasps that emerge from these cocoons attack 5th and 6th instar caterpillars of *E. aurinia* in April before they reach pupation. Affected caterpillars harbour many wasp larvae and these erupt in the summer, producing a mass of cocoons. This summer generation of wasps attacks early instar caterpillars of the next generation of *E. aurinia* and wasp larvae enter hibernation with *E. aurinia*, emerging in the spring to complete the cycle. Some of these wasp larvae develop early, emerge and spin cocoons before the hibernation of *E. aurinia*, producing a third, autumn generation of wasps. These attack caterpillars of *E. aurinia* just before or while they are in hibernation (pers. obs.).

METHODS

General

Two visits were made to Tiree in 2017, in spring (9th - 11th April) and autumn (8th - 10th October). These were timed to coincide with respectively the spring moult of 4th instars when wasp cocoons, especially those of *C. melitaearum*, are most visible, and the autumn moult of 3rd instars and hibernation of 4th instars when cocoons of *C. bignellii* (and sometimes adults) can be found in late feeding webs and final moult webs. This information was obtained outwith Tiree through monitoring the development of caterpillars on Islay and mainland Argyll.

Both visits were timed well, although the development of caterpillars on Tiree lagged slightly compared with elsewhere in 2017. Searches were made for webs in suitable habitat when it was encountered on the ground within 200 m x 200 m units of 1 km squares (therefore a 1 km square was composed of 25 such units).

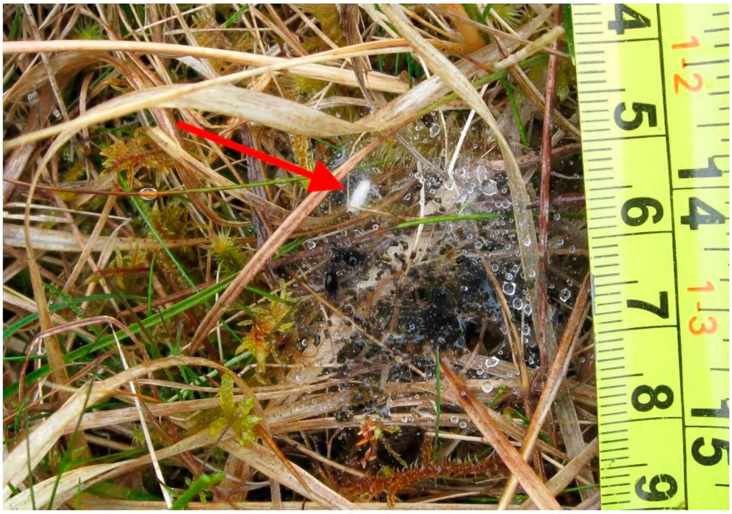

Fig. 1. A cocoon of the parasitoid wasp *Cotesia melitaearum* (arrowed) inside an empty spring moult web of the marsh fritillary (*Euphydras aurinia*) on Tiree, Scotland, April 2017. (Photo: N.O.M. Ravenscroft)

Spring

Surveys for webs in the spring focused on four lochs on the "sliabh" of Tiree, an expanse of wet, peaty ground in the centre of the island on which *E. aurinia* had been seen in 2014-2016 (Fig. 2). These were Loch na Gile (NM027481), Loch Riaghain (NM034471), Loch a' Bhleoghainn (NM021456) and Loch Leana na Moine (NM028446), as well as areas beside the B8069. The location (10 figure grid reference) of all webs found was recorded using a GPS and the number of cocoons in each web was counted. Webs were broken and searched if caterpillars had vacated them. All cocoons were collected.

Autumn

Surveys were repeated within the spring search area but also expanded to encompass adjacent and new areas, especially around Loch Caol (NM030454) (Fig. 2), primarily because of the paucity of webs of *E. aurinia*. The locations of all webs that were located were recorded and all empty webs were broken and searched for cocoons. To provide a baseline for future monitoring, transects were walked during which the numbers of *E. aurinia* webs were recorded in standard fashion (counted 1 m either side of the observer and route length recorded).

RESULTS

Spring

Eighty nine webs of *E. aurinia* were located in 11 of 35 survey units during spring 2017 (Fig. 3A). Concentrations of webs were found in three survey units, one each beside Loch Riaghain, Loch a' Bhleoghainn and Loch Leana na Moine (these three units contained 67 webs or 75% of the total).

Remaining webs were spread thinly and almost half of occupied search units contained two or fewer webs.

Most caterpillars of *E. aurinia* were 4th instars in webs and were either approaching moult or were at moult. Small 5th instars occurred in and around these webs indicating freshly moulted caterpillars. Some larger 5th instars and several 6th instars occurred in some survey units, and these occupied a further seven units in the absence of any evidence of 4th instars.

Cocoons were found in 47 webs (i.e. 53% or about one in two webs contained cocoons). Ninety nine cocoons were found in total, i.e. about two per parasitised web overall, but up to seven occasionally (Fig. 4). Numbers of webs and cocoons in units were correlated highly (Spearman's $r = 0.91$, $P = 0.001$); 85% of cocoons occurred in three survey units that contained 75% of the population of *E. aurinia*. Cocoons were not found in four of the five units that contained only one or two webs of *E. aurinia* (Fig. 3B).

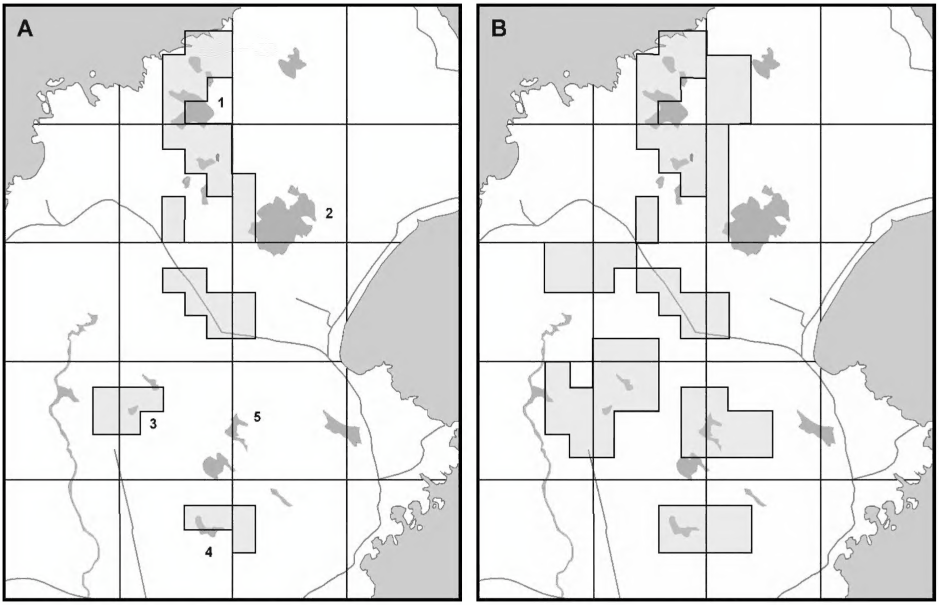

Fig. 2. Maps of the sliabh of Tiree, Scotland, on which searches for *E. aurinia* caterpillars were performed within the shaded areas during (A) spring 2017 and (B) autumn 2017. Search areas are shown against a background of water bodies (dark grey), roads and the 1 km grid. 1, Loch na Gile; 2, Loch Riaghain; 3, Loch a' Bhleoghainn; 4, Loch Leana na Moine; 5, Loch Caol.

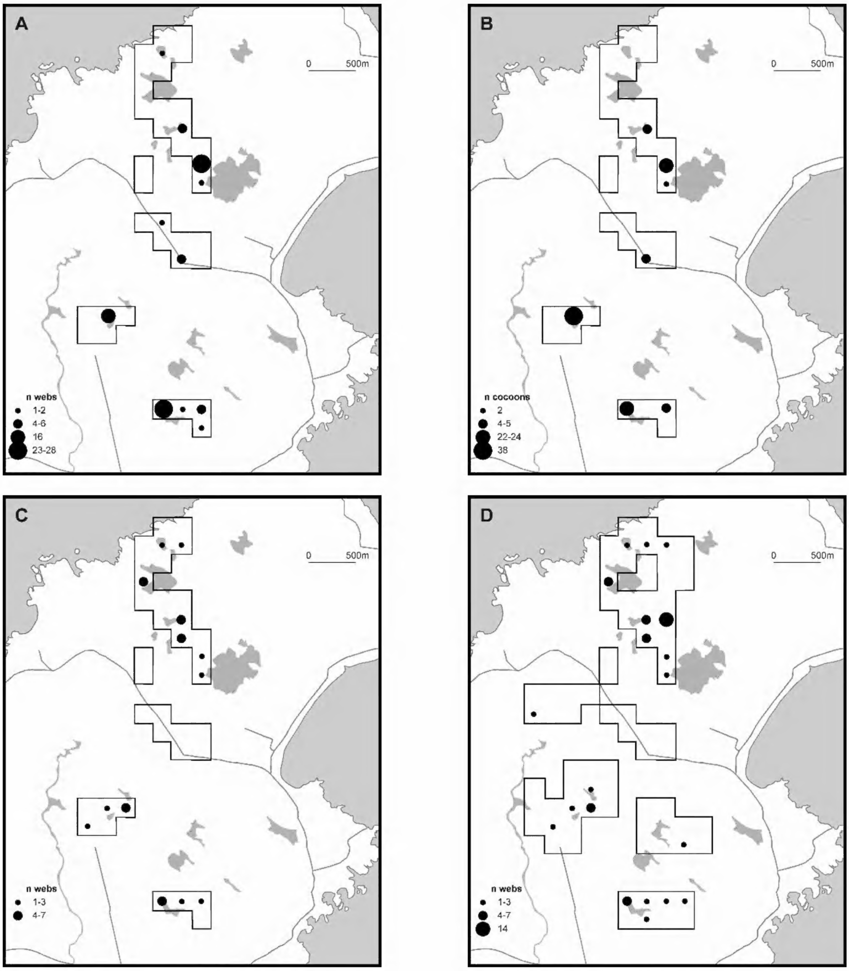

Fig. 3. Maps of the sliabh of Tiree, Scotland, showing the distributions and numbers in 2017 of (A) webs of 4th instar caterpillars of *E. aurinia* in spring, (B) cocoons of *C. melitaearum* in spring, (C) webs of *E. aurinia* in autumn within the same search area, and (D) webs of *E. aurinia* in autumn within the wider search area.

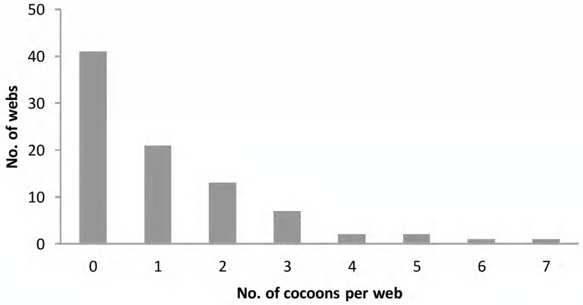

Fig. 4. The frequency of cocoons of *C. melitaearum* in webs of *E. aurinia* on Tiree, Scotland, in spring 2017.

All wasps that hatched from collected cocoons were *C. melitaearum*: 36 males and 57 females (six cocoons did not hatch). Sex ratios were biased towards females at Loch a' Bhleoghainn (males:females 7:28), but equal elsewhere (29:29). Parasitism rates were high at Loch a' Bhleoghainn where 75% of webs contained at least one cocoon and 38 cocoons occurred in 12 parasitised webs.

Autumn

Webs occurred at a lower density than in the spring (Fig. 3C). Thirty nine webs were located in 13 survey units, usually in small numbers (only one to three webs were found in eight of these squares). Spring and autumn distributions were not correlated (r = -0.12). The web total increased to 64 in 20 of 77 survey units in the expanded survey area, again occurring most usually as scattered webs (one to three webs were found in 14 of these units; Fig. 3D). Only one concentration of webs was recorded.

Most caterpillars had entered hibernation: 51 webs were empty final moult webs and the other 13 webs contained 4th instars. All the former were broken and searched but no wasp cocoons were found and none was observed in occupied webs.

DISCUSSION

Colonisation or persistence?

The occurrence of *C. melitaearum* on Tiree indicates strongly that *E. aurinia* was present before its discovery in 2014. The wasp is unlikely to have reached Tiree naturally since then, or colonised the extent of the island in which it was recorded in 2017. For example, each generation of the *C. melitaearum* agg. that attacks the Glanville fritillary *Melitaea cinxia* in Finland has a typical range of less than 500 m (Lei & Camara, 1999; van Nouhuys & Hanski, 2002). Owing to its restricted mobility, the wasp exists only in well-connected and enduring populations of *M. cinxia* and becomes concentrated in areas of high host density (Lei & Hanski, 1998; van Nouhuys & Hanski, 2002). This is exactly what was found on Tiree, where *C. melitaearum* occurred almost exclusively in concentrations of *E. aurinia* and the numbers of cocoons and webs were correlated. This gives every indication that both *C. melitaearum* and *E. aurinia* are well established on the island.

The failure to locate *C. bignellii* is inconclusive, as it is more cryptic than *C. melitaearum,* and its range in Scotland outside Islay is unknown. Furthermore, although *C. bignellii* had an autumn generation on Islay for three years after its discovery, none were found on the island in the autumns of 2017 or 2018. The synchrony between wasps and *E. aurinia* larvae early in the summer probably affects the occurrence of the autumn generation and it is believed to be partial (Porter, 1983). Therefore, the lack of cocoons does not indicate that *C. bignellii* is absent. It is interesting that the flightless ichneumonid *Gelis* sp., a generalist hyper-parasitoid of the wasps that is common in cocoons of both species on Islay, was not found on Tiree.

How long *E. aurinia* has been on Tiree is impossible to predict but it is conceivable that it has persisted since 1950. Populations drop to extremely low levels in Scotland and caterpillars can be extremely difficult to find. At these times they can escape casual observation, as has been noted in England (Porter, 1990). For example, marsh fritillaries declined to such low levels at one well-studied site in Cumbria from a period of abundance in the late 19th century, when larvae occurred in "swarms", that it was only observed occasionally during thorough searches for nearly 20 years, until a second period of super-abundance (Ford & Ford, 1930). On Islay, numbers may drop so low that an impression of absence or local extinction can be gained by standard survey techniques, but protracted searches often reveal its presence, usually only when repeated. The species is difficult to record at these times, and a recorded absence over larger areas that it is known to occupy, even after searches by experienced observers, could be no more than an indication of very low density.

Heslop Harrison (1943, 1946) recorded the marsh fritillary on Tiree and more widely in the Inner Hebrides, including Coll, Gunna and Rum but, as with many of his records, it has not been seen since on these islands. Although the veracity of some of his records has been questioned, there is no reason to doubt those of *E. aurinia* and it seems probable that Heslop Harrison was active during a spell of abundance for it to be recorded so readily. Recently, the butterfly has been found on Eigg after an absence of nearly 30 years where it was found to be widespread; and it has been re-located on Gunna since the discovery on Tiree (J. Bowler, pers. comm.). It has also been recorded on Bute after a protracted absence, and subsequently found to occur more widely (NBN Atlas, 2016).

Numerous biological surveys have been performed on Tiree since Heslop Harrison's time, some of which covered the areas in which *E. aurinia* occurs currently (e.g. Shepherd & Stroud, 1991). In the early days, sightings of *E. aurinia* may not have been noteworthy as it was known to occur on the island. Latterly though, wildlife awareness is high amongst both resident and visiting naturalists. Bird surveys continue to cover the sliabh but these tend to be early morning and at a time of year when *E. aurinia* is either a caterpillar, pupa or in hibernation. Adult butterflies are imperceptible in any case during periods of poor weather, especially during low ebbs in the population. In recent times *E. aurinia* has been abundant in western Scotland only in 1978, 1985, 1990-91, 1997-98, 2006-07 (when it was found on Bute) and 2013-14 (when it appeared on Eigg and Tiree) (Ravenscroft, 2013).

It seems probable that *E. aurinia* has been on Tiree since 1950 or, even if absent occasionally, it may have persisted on nearby Gunna or Coll, which are *ca.* 1 km distant. The butterfly is a poor disperser with distances moved generally small (<500 m: Schtickzelle *et al.*, 2005), and although butterflies are thought to disperse a few kilometres on occasions (Porter, 1990), this is over land. Crossing 30 km of sea against the prevailing wind is a different matter. During many years of observation in an island landscape in Finland, the longest distance achieved by *M. cinxia*, a species related closely to *E. aurinia* and of similar size and population structure, was 6.5 km (van Nouhuys & Hanski, 2002).

Human beings may have facilitated the original colonisation of Tiree by *E. aurinia* and *C. melitaearum*, perhaps through the transport of hay, livestock or fuel. Eggs of *E. aurinia*, wasp cocoons or young caterpillars infected with wasp eggs or larvae, might have persisted in local, fresh summer-cut hay that was imported or carried with the transport of livestock. Peat used to be cut on Mull and brought to the island after the supply on Tiree was exhausted (Banks, 1977), but this practice stopped in the 1950s with the advent of coal brought by puffers (J. Bowler, pers. comm.). Hay is still imported, but from distant sources and only as silage.

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Thysanoptera caught by emergence trapping from oak trees at Hamilton High Parks, South Lanarkshire, including *Hoplothrips semicaecus* (Uzel) new to Scotland

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ABSTRACT

A survey of the saproxylic invertebrate fauna of the Cadzow oaks parkland, South Lanarkshire, Scotland, part of the Hamilton High Parks Site of Special Scientific Interest, was undertaken between April 2017 and April 2018, with additional prior test trapping having started in August 2016. Several different search methodologies were utilised, including Owen emergence traps, flight interception traps, hollow tree traps, and rot hole traps. Large numbers of a non-target group of insects - thrips (Order Thysanoptera) - were noted in some of the traps from the first batch to be examined and separated out for analysis. A total of 370 individuals from eight species was identified, with 85.1% of these thrips being collected by three Owen emergence traps, a novel methodology for determining the presence, or abundance, of dispersing Thysanoptera. The majority (92.4%) of the thrips represented two fungal-feeding phlaeothripid species, *Hoplothrips pedicularius* and *H. semicaecus*. This is the first report of *H. semicaecus* from Scotland.

INTRODUCTION

Hamilton High Parks is a 30.7 hectare site immediately south-east of Hamilton, South Lanarkshire, Scotland, which encompasses an area of semi-natural ash- and elm-dominated (*Fraxinus* spp. or *Ulmus* spp.) gorge woodland, and two separate areas of wood pasture containing parkland oaks. It is designated as a Site of Special Scientific Interest (SSSI) not only for these two types of woodland plant communities, but also for the rich saproxylic (depending on dead or decayed wood) beetle assemblage associated with the area of open canopy wood pasture containing 300 or more common oak trees (*Quercus robur*) that are known collectively as the Cadzow oaks (Fig. 1). The site is one of two Scottish mediaeval deer forests with many of the trees over 400 years old, and as a result the parkland is rich in dead wood content. There are fallen limbs at the base of standing trees and a number of trees exhibit hollowed out trunks.

During the 1950s and early 1960s, the renowned coleopterist Roy Albert Crowson (1914-1999) and his wife Elizabeth Anne ("Betty") Crowson (1928-2006), also a keen naturalist, collected invertebrates at Hamilton High Parks, predominantly saproxylic Coleoptera. The many rare and interesting species that they uncovered, including a number of 'Nationally Scarce' beetle species, are in part responsible for the site being designated a SSSI. Many of their specimens and notes from Hamilton High Parks, as well as those collected from Clyde Valley and other local woodland sites, were deposited in the Hunterian Museum, University of Glasgow. The Crowsons' findings were published in several journals including *The Glasgow Naturalist* (e.g. Crowson, 1962, 1964, 1979; Crowson *et al*., 1966).

Fig. 1. Hamilton High Parks, South Lanarkshire, Scotland: wood pasture containing parkland oaks (*Quercus robur*). (Photo: J. Robinson)

These earlier invertebrate surveys inspired a project to return to Hamilton High Parks and undertake a modern investigation, comparing the findings with those from the 1950s and 1960s. Initial test trapping and qualitative sampling began in August 2016. This was followed by a more comprehensive survey of the saproxylic invertebrate fauna of the Cadzow oaks parkland, carried out over 12 months, between April 2017 and April 2018. The primary targets were beetles and spiders, in order to allow comparison with the findings made by the Crowsons, with saproxylic flies also targeted to further enhance knowledge of the site and ultimately help inform site management. Full results of this work will be published in due course. However, during analysis of the catch from the first batch of traps to be examined, which included trap catches from both during the initial test trapping phase and the main survey, the presence of large numbers of a non-target group of insects - thrips (Order Thysanoptera) - was noted in some of the traps. These thrips were isolated for separate examination and evaluation, and the results are presented here, including the occurrence of a species not previously recorded from Scotland.

METHODS

The primary, year-long, survey commenced on 14th April 2017. Sampling utilised a number of trapping methodologies including: 20 flight interception traps (ten hanging in the oak canopy and ten attached to the oak trunks); ten water traps (situated inside the hollow oak trunks); ten rot hole emergence traps; and ten Owen emergence traps filled with wood in varying states of decay, including wind fallen branches with relatively fresh growth, rotten tree sections with and without bark, and sections of loose bark (Fig. 2).

Once set up, traps were left *in situ* for a full calendar year. In addition, prior to the main survey, the sampling protocol had been tested with one of each type of trap set up on 25th August 2016. In all cases, traps were checked at approximately two or three weekly intervals, occasionally at longer intervals, with the catch being removed for storage and analysis. Traps were all custom built, with a solution of 50% polypropylene glycol and 50% water placed in the trap collection bottles. There was also some qualitative searching by hand, and funnel extraction of heart rot and under loose bark. Specimens were rinsed with water and transferred to 70% ethanol for storage prior to sorting to Order level. Processing of the trap catches remains ongoing as resources, including the availability of taxon specialists, allow; trap catches are not being processed in chronological order. All survey work was planned and supervised by JR, EGH, LM and JS; trap construction, installation, monitoring, and specimen sorting were supported by numerous invaluable volunteers who are acknowledged below.

Thrips were slide mounted in Canada balsam according to standard methodology (Mound *et al.*, 2018), examined under a GT Vision GXM-L2800 compound microscope at a magnification of up to ×400, and identified using both the key in Mound *et al.* (1976) and a trial version of the subsequently published online key to British and Irish Thysanoptera (Mound *et al.*, 2018). Confirmation of specific identity was made by comparison with material in the Thysanoptera collection of the Natural History Museum, London (NHM). All slide preparation, identification and evaluation of the thrips found was carried out by DWC.

Voucher specimens have been deposited in the collections at The Hunterian Museum and in the private collection of DWC.

RESULTS

A total of 370 individual adult thrips was identified from this first batch of trap catches, representing eight species: *Aptinothrips rufus* Haliday, *Limothrips cerealium* Haliday, *L. denticornis* Haliday, *Oxythrips bicolor* (Reuter), *Thrips fuscipennis* Haliday (all Thripidae), *Hoplothrips fungi* (Zetterstedt), *H. pedicularius* (Haliday) and *H. semicaecus* (Uzel) (all Phlaeothripidae). Thrips were taken from 17 different trap catches, comprising 12 catches from seven separate Owen emergence traps, two from a single aerial flight trap, two from a single rot hole trap, and one from a hollow tree trap. Their occurrence was highly aggregated with 315 individuals (85.1%) taken from just four trap catches, from three Owen emergence traps. Furthermore, two species - *Hoplothrips pedicularius* and *H. semicaecus* (Fig. 3) - accounted for 92.4% of all the individuals collected. The results are presented in Table 1.

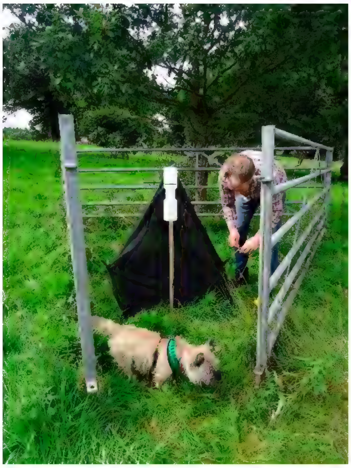

Fig. 2. An Owen emergence trap being set up at Hamilton High Parks. (Photo: J. Robinson)

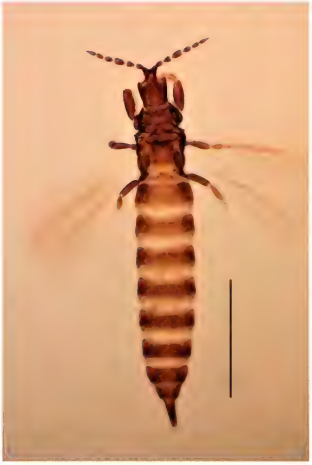

Fig. 3. *Hoplothrips semicaecus*. An adult macropterous female (slide-mounted, body distended). Scalebar = 1 mm. (Photo: D.W. Collins)

		Thripidae					**Phlaeothripidae**		
Sample Date	**Trap description/reference**	*Aptinothrips rufus*	*Limothrips cerealium*	*Limothrips denticornis*	*Oxythrips bicolor*	*Thrips fuscipennis*	*Hoplothrips fungi*	*Hoplothrips pedicularius*	*Hoplothrips semicaecus*
25.8.16 - 8.9.16	Owen emergence trap 4	1[a]	1	-	-	2	-	-	-
5 - 22.9.16	Owen emergence trap 4	-	-	-	-	-	1	-	130
5 - 22.9.16	Rot hole trap 50	-	-	-	-	-	-	-	6
6 - 23.10.16	Aerial flight trap 1	-	-	-	-	-	-	-	1
6 - 23.10.16	Owen emergence trap 4	-	-	-	-	-	-	-	6
18.10.16 - 1.11.16	Owen emergence trap 4	-	-	-	-	-	1	-	70
17.11.16 - 1.12.16	Aerial flight trap 1	-	-	-	-	-	-	-	1
17.11.16 - 1.12.16	Owen emergence trap 4	-	-	-	-	-	-	-	5
1 - 31.12.16	Owen emergence trap 4	-	-	-	-	-	-	-	1
6 - 28.4.17	Rot hole trap 50	-	-	-	1	-	-	-	-
12 - 25.5.17	Owen emergence trap 21	-	-	11	-	-	-	-	-
12 - 25.5.17	Owen emergence trap 22	-	-	2	-	1	-	1	-
8 - 29.6.17	Owen emergence trap 23	-	-	-	-	-	1	53[b]	-
8 - 29.6.17	Owen emergence trap 24	-	-	-	-	-	-	-	1
8 - 29.6.17	Owen emergence trap 28	-	-	-	-	-	5	3	-
8 - 29.6.17	Owen emergence trap 29	-	-	-	-	-	-	62[c]	2
18.12.17 - 11.1.18	Hollow tree trap 39	-	-	-	-	-	1	-	-
	Total	1	1	13	1	3	9	119	223

Table 1. Thysanoptera caught by emergence, and other forms of, trapping at Hamilton High Parks, South Lanarkshire, Scotland. Each trap number refers to a single trap kept in place at a specific location, either though the autumn of 2016 and winter of 2017 (test traps) or for a full calendar year commencing 14th April 2017 (main survey). All individuals are macropterous females except as annotated: [a]apterous species - one adult female; [b]figure quoted includes four macropterous males; [c]figure quoted includes two macropterous males.

DISCUSSION

Hoplothrips is a large genus of about 120 nominal species found around the world, whose members occur on the branches and trunks of dead angiosperm trees. Most are presumed to feed on fungal hyphae, though *H. pedicularius* is often associated with brackets of *Stereum* fungi. Many of the commonest species in the genus, including all three species found at Hamilton High Parks, exhibit wing polymorphism. Both sexes of *H. fungi* and *H. pedicularius* produce macropterous and micropterous morphs, whilst females of *H. semicaecus* may be either macropterous or apterous (only apterous males are known). Wing reduction in *Hoplothrips* species and a tendency to gregariousness, which is generally common in mycophagous phlaeothripid species, are probably adaptions that allow maximal exploitation of fungal resource on dead wood once located. The strong sexual dimorphism and associated subsocial behaviour found in *H. pedicularius* has been particularly well studied (Crespi, 1986). The literature on the underlying causes of differential wing morphs in fungal-feeding phlaeothripids, including *Hoplothrips* species, was surveyed briefly by Kobro & Rafoss (2006). Whether production of fully-winged morphs indicates a phenotypic reaction to sub-optimal food availability or quality, or whether some other causal trigger is involved, is not clear. At Hamilton High Parks, all the *H. pedicularius* adults that have been identified so far emerged from the dead wood in Owen emergence traps 55 to 76 days after the traps were set up. Likewise, the overwhelming majority of *H. semicaecus* adults emerged either 11 to 28 days or 54 to 68 days after the traps were set up. However, all the *H. pedicularius* adults emerged in May and June of 2017, whereas nearly all the *H. semicaecus* adults emerged during the autumn of 2016, an apparent phenological distinction. But, in the collections of the NHM there are macropterous adult females of *H. pedicularius* from Scotland, taken in September and December, and macropterous adult females of *semicaecus*, from England, taken in March, July and August. Three individuals of *H. semicaecus* emerged in June 2017 during this study. Similarly, whilst Morison (1947-1949) noted that macropterous individuals of *H. fungi* migrate in July, two such individuals were found here in the autumn of 2016.

Both *H. fungi* and *H. pedicularius* are common and widespread in Great Britain including the Scottish mainland. Morison (1947-1949) reported the occurrence of large colonies of both species in north-east Scotland, with those of *H. pedicularius* sometimes numbering thousands of individuals and capable of persisting for years. By contrast, this is the first finding of *H. semicaecus* from Scotland, and it is clearly well-established at Hamilton High Parks. It has previously been recorded from the southern half of England as well as from Durham and South Yorkshire (Mound *et al.*, 1976; Collins, 2011), and is widespread across Western and Central Europe. However, it appears to become less common in more northerly latitudes and, for example, appears to be rare in both Norway and Sweden in contrast to *H. pedicularius* and, in Norway at least, *H. fungi* (Kobro & Rafoss, 2006; Gertsson, 2015). The species is also found in North America, Japan and New Zealand. The number and form of the emergent sense cones on the fourth and fifth antennal segments have been used to help distinguish some of the British species of *Holothrips*. The macropterous female of *H. semicaecus* is unique within the genus in also possessing numerous small sense cones on the ventral surface of the fourth and fifth antennal segments (Fig. 4). The number of emergent sense cones on antennal segments III and IV is variable; the Cadzow oak specimens all exhibit the combination of three sense cones on segment III and four on segment IV, which matches single specimens collected from South Yorkshire (Collins, 2011) and Buckinghamshire (Collins, unpublished data) in the last decade. By contrast, NHM specimens from the 20th century have two sense cones on each segment. The significance of this is unknown, though specimens with the same combination of sense cones as was found at Hamilton High Parks have been recorded in Japan (Okajima, 2006), whilst the number of sense cones on antennal segment IV of macropterous adult females from New Zealand varies between two and four (Mound & Walker, 1986).

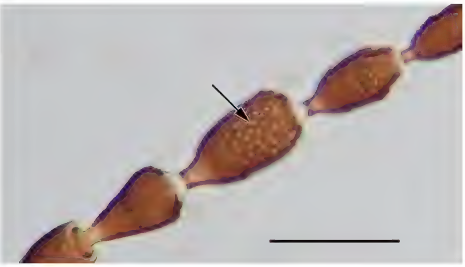

Fig. 4. *Hoplothrips semicaecus*. Antennal segments III-V, showing the cluster of ventral sense cones on segment IV (arrow). Scalebar = 80 µm. (Photo: D.W. Collins)

Small numbers of five phytophagous thripid species were also taken, four of which are common and widespread species. All have previously been recorded from “Lanarkshire” (Mound *et al.*, 1976), except *O. bicolor*, a species found on male cones of Scots pine (*Pinus sylvestris*), which has been widely recorded from north and north-east Scotland. Many terebrantian thrips overwinter in the soil, but some species, including *L. cerealium* (and probably *L. denticornis*), are known to overwinter as adults under tree bark (see e.g. Lewis, 1962).

Collection records and comparative personal experience suggest that fungal-feeding Phlaeothripidae were more readily collected in Britain up into the middle decades of the last century than they are today (L.A. Mound, pers. comm.). However, the precise reasons for this are unclear, and the effect may be partially the result of sample bias. Thrips are generally taken only from plants within easy reach of the collector, and changes in forestry practice combined with an apparent decrease in insect abundance in recent decades (Leather, 2018) may be contributory factors. Very few studies looking at the insect fauna in tree canopies in Britain have included the Thysanoptera, and as a result there is scant available information concerning those thrips that may be found there. In Britain, a repeat canopy fogging (i.e. insecticide spraying) exercise on common oak trees in Richmond Park, London, between April and October 1984 yielded large numbers of the predatory phlaeothripid species *Haplothrips subtilissimus* (Haliday) and the phytophagous thripids *Drepanothrips reuteri* Uzel and *Thrips major* Uzel (Palmer, 1986). The finding of large numbers of the otherwise rarely collected *D. reuteri* from the tree canopies was illustrative of the limitations of our knowledge of the biology of even the comparatively well characterised British thrips fauna. Among the remaining 19 species collected were small numbers of the fungal-feeding phlaeothripid species *Hoplandrothrips ellisi* Bagnall, *Hoplothrips pedicularius*, *Hoplothrips ulmi* (Fabricius) and *Phlaeothrips coriaceus* Haliday, as well as six adult specimens of an apparently undescribed species of *Hoplothrips* (although the specimens do not appear to be extant). A canopy fogging study of three oak trees in the Wyre Forest, Worcestershire, in June and July of 2015 yielded five fungal-feeding phlaoethripid species (*Hoplothrips fungi*, *H. corticis* (De Geer), *H. pedicularius*, *H. semicaecus* and *Phlaeothrips coriaceus*) (Skirrow, 2017).

Several studies utilising emergence trapping of adult terebrantian thrips from the soil and leaf litter in orchards have been published (e.g. Parker & Skinner, 1993; Childers *et al*., 1994; Gilbert & Samways, 2018). Other studies have used simple flight interception traps in order to specifically monitor phlaeothripids, whether yellow sticky traps to study the movement of *Gynaikothrips uzeli* (Zimmerman) adults between weeping fig (*Ficus benjamina*) plants in a nursery in Mississippi, U.S.A. (Held & Boyd, 2008) or screen traps in Polish forests to determine the local presence of fungal-feeding species including several *Hoplothrips* species (Kucharczyk *et al*., 2015). Orosz *et al*. (2016) used Rothamsted-type suction traps to study mass flight of phlaeothripids in Hungary. In Norway, Kobro (2001) deposited field-collected Norway spruce (*Picea abies*) bark in Berlese funnels in order to detect *H. polysticti* (Morison), whilst arboreally-placed photoeclectors have been used to sample bark-living thrips in Slovakia (Duboyský *et al*., 2010). However, the current authors are not aware of any previous studies using Owen emergence traps to determine the presence, or abundance, of dispersing Thysanoptera. This style of trap is particularly good for targeting species associated with wood and its decay products selectively, as it is a closed unit.

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First records of tardigrades (Tardigrada) from Irish and Scottish leaf litter

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ABSTRACT

The findings of an investigation of the tardigrade fauna associated with beech (*Fagus sylvatica*) leaf litter in the Republic of Ireland and Scotland are reported. The present study is the first to specifically target this microhabitat in either country. Tardigrades were extracted from 16 samples of leaf litter obtained from seven locations (one in Ireland and six in Scotland). Twenty five tardigrade taxa were encountered including seven that represent new records for the Republic of Ireland (*Pseudechiniscus* sp. nov., *Diphascon pingue* group sp., *Hypsibius* cf. *convergens*, *Hypsibius* cf. *scabropygus, Itaquascon* cf. *globuliferum*, *Ursulinius* sp. nov., and *Minibiotus* sp. nov.) and four for Scotland (*Bertolanius weglarskae, Hypsibius* cf. *scabropygus*, *Adropion belgicae* and *Pilatobius ramazzottii*). The collection of several taxa that either represent new records or undescribed species within a small number of samples demonstrates the importance for researchers to include leaf litter when assessing and reporting the tardigrade biodiversity of an area.

INTRODUCTION

Tardigrades (phylum Tardigrada) are microscopic, invertebrates that require a film of water around their bodies to maintain normal activity. However, they are well known for their ability to survive periods of desiccation and other unfavourable environmental conditions. As a consequence, tardigrades are capable of inhabiting diverse marine, freshwater and moist terrestrial habitats worldwide (Kinchin, 1994; Sømme, 1996; McInnes, 1994; Guidetti *et al.*, 2011).

Despite their seemingly ubiquitous nature (e.g. Nelson, 2002; Nelson *et al.*, 2019), knowledge of the limno-terrestrial tardigrade fauna of the Republic of Ireland (hereafter referred to as "Ireland"), Scotland and the remainder of the U.K. is predominantly based on studies of mosses and lichens as microhabitats (e.g. Murray, 1905a, 1905b, 1906a, 1906b, 1907, 1911a, 1911b; Le Gros, 1955, 1957; Morgan, 1976; Morgan & King, 1976; Wright, 1991; DeMilio *et al.*, 2016; Morek *et al.*, 2016; Stec *et al.*, 2017). Other studies carried out in England included rain gutter sediment (Bertolani & Kinchin, 1993) or a small number of leaf litter samples among more numerous mosses or lichens (Greaves, 1991; Greaves & Marley, 1994; Nattress *et al.*, 2014). To date no studies on tardigrades associated with the leaf litter habitat have been undertaken in Ireland or Scotland. The present study therefore represents the first attempt to collect data on the tardigrade species inhabiting leaf litter in either country.

Although it has long been known that tardigrades occur in leaf litter (Mihelčič, 1949), globally there have been relatively few studies reporting on the abundance and species richness of tardigrades in this habitat (e.g. Iharos, 1967, 1973; Hallas & Yeates, 1972; Greaves, 1991; Greaves & Marley, 1994; Beasley & Cleveland, 1996; Bertolani & Rebecchi, 1996; Guidetti *et al.*, 1999; Guidetti & Bertolani, 2001; Ito & Abe, 2001; Hohberg, 2006; Hinton & Meyer, 2007; Nelson & Bartels, 2007; Guil, 2008; Guil *et al.*, 2008, 2009; Hinton *et al.*, 2010, 2014; Guil & Sánchez-Moreno, 2013; Nelson & Bartels, 2013; Nattress *et al.*, 2014; Meyer, 2015; Roszkowska *et al.*, 2019). Of these, five are known to have included beech (*Fagus sylvatica*) leaf litter. Beech litter was found by Guil & Sánchez-Moreno (2013) to harbour the most diverse composition of tardigrade taxa among the compared leaf litter types. Some tardigrade species previously recorded from beech litter were reported from across a broad geographical area (Guidetti *et al.*, 1999). As these included several species not previously found within Ireland and the U.K., it was hypothesised that an examination of Irish and Scottish beech litter could reveal the presence of species new to the Irish and U.K. fauna and contribute to a better understanding of the distribution of tardigrades and their ecological associations in both countries.

MATERIALS AND METHODS

Sixteen samples of beech leaf litter were opportunistically collected; ten from throughout a single woodland site in Ireland, Barna Woods, Co. Galway (B1–B10); and six separate sites in Scotland with four samples from the north east (Aberdeenshire and Morayshire), one sample from the Lake of Menteith, Stirlingshire, and one sample from the western shore of Loch Ness, Highland. As far as possible the inclusion of soil was prevented by taking samples from a minimum of 1.5 cm above the underlying soil. The collection of mixed leaf litter was also avoided.

Samples were either processed immediately or retained to dry in paper envelopes. In each case a small sample (weighing approximately 15–25 g) of leaf litter was soaked for up to 24 h before being agitated by hand and squeezed into shallow trays. Tardigrades, eggs, and exuvia were removed and mounted on glass slides in polyvinyl alcohol (Irish specimens) or Hoyer’s medium (Scottish specimens) and secured with a cover slip. Slides were dried at approximately 22°C (Irish material) for two days or 60°C (Scottish material) for five days before being sealed with clear nail varnish. Juvenile animals were observed but not included in the species total counts. Specimens were examined on an Olympus BX51 with up to x100 oil immersion lens and x2 magnification changer with differential interference contrast (DIC), and phase contrast (PhC) optics. Photographs and measurements of specimens were obtained using Cell D software (dp2020). Measurements were taken following Pilato (1981) except where otherwise noted and are given in micrometres (μm). The *pt* index is the ratio of the length of a given structure to the length of the buccal tube, expressed as a percentage (Pilato, 1981). The *ptd* index (Pilato & Binda, 1997/98) is used to obtain a similar ratio for taxa that have an evident drop-shaped thickening between the rigid buccal tube and flexible pharyngeal tube, as the buccal-pharyngeal apparatus configuration requires a different caudal reference mark for the buccal tube measurement. Individual structures were measured only if their orientation was suitable.

Identifications of specimens were made via comparisons with the original species descriptions, additional relevant literature, or by comparisons with type material whenever possible. Natural History Museum of Denmark (NHMD) catalogue numbers of the examined material are given below. The taxonomic account and systematics follow the most recently available checklist of tardigrade species (Guidetti & Bertolani, 2005; Degma & Guidetti, 2007; Degma *et al.,* 2019). Usage of open nomenclature follows the recommendations of Sigovini *et al.* (2016).

Sample locations

Ireland: Barna Woods, County Galway, Ireland. Date of collection: 20/06/2016

Irish grid reference: ‘M24442378’
B1. 53°15′31″N, 9°07’54″W, Alt. 26.2 m
B2. 53°15′35″N, 9°07’43″W, Alt. 28.0 m
B3. 53°15′36″N, 9°07’60″W, Alt. 30.1 m
B4. 53°15′34″N, 9°08’01″W, Alt. 33.1 m
B5. 53°15′37″N, 9°08’03″W, Alt. 32.9 m
B6. 53°15′41″N, 9°07’53″W, Alt. 26.0 m
B7. 53°15′41″N, 9°07’33″W, Alt. 26.2 m
B8. 53°15′51″N, 9°07’02″W, Alt. 24.5 m
B9. 53°13′50″N, 9°07’09″W, Alt. 27.5 m
B10. 53°15′50″N, 9°07’56″W, Alt. 24.1 m

Scotland: Dates of collection: 07/11/2015 and 30/04/2016

Battle Hill, Huntly, Aberdeenshire. 57°26′56″N, 2°45′40″W, Alt. 175 m
Fochabers, Winding Walks Wood, Morayshire. 57°36′26″N, 3°04′16″W, Alt. 154 m
Invermoriston, Loch Ness, Highland. 57°12′40″N, 4°36′48″W, Alt. 49 m
Lake of Menteith, Stirlingshire. 56°10′22″N, 4°16′25″W, Alt. 27 m
Leith Hall, Kennethmont, Aberdeenshire. 57°21′14″N, 2°45′41″W, Alt. 181 m
Slug Road, Stonehaven, Aberdeenshire. 56°59′12.43″N, 2°15′40″W, Alt. 58 m

RESULTS

All 16 samples contained tardigrades (Table 1). In total 506 (including five encysted) adult individuals, and 81 eggs were collected. The number of adult individuals per sample ranged from two to 130. Twenty-five taxa were represented. Seven taxa have not been previously recorded from Ireland. Four taxa have not been previously recorded from Scotland.

Taxonomic Account

Class Heterotardigrada Marcus, 1927
Order Echiniscoidea Richters, 1926
Family Echiniscidae Thulin, 1928
Subfamily Echiniscinae Guil, Jørgensen & Kristensen, 2019
Tribe Echiniscini Guil, Jørgensen & Kristensen, 2019

Echiniscus quadrispinosus quadrispinosus (Richters, 1902)
Scotland: Leith Hall, one adult.
The collected specimen was typical of the species. This is the first known record of the species from leaf litter.

Subfamily Pseudechiniscinae Guil, Jørgensen & Kristensen, 2019
Tribe Pseudechiniscini Guil, Jørgensen & Kristensen, 2019

***Pseudechiniscus* sp. nov.**
Ireland: Barna Woods: B5, 1 adult; B8, 2 adults.
One male and two females specimens belonging to the genus *Pseudechiniscus* Thulin, 1911 were collected. Following a comparison with the descriptions all known species of the genus it was determined that the Irish specimens could not be assigned to any known taxon due to the unique morphology of the cephalic sense organs.

The recent works of Cesari *et al.* (2019) and Tumanov (2019) have addressed the taxonomic difficulties associated with *Pseudechiniscus.* Despite the advancements presented by these authors, the *P. suillus-facettalis* species complex remains particularly problematic in the absence of a re-description of *P. suillus* (Ehrenberg, 1853), the nominal species of the complex and genus type. While the morphology of the cephalic sense organs of the collected specimens clearly

Taxon	**B1**	**B2**	**B3**	**B4**	**B5**	**B6**	**B7**	**B8**	**B9**	**B10**	**BH**	**FO**	**IN**	**LM**	**LH**	**SR**
Echiniscus quadrispinosus quadrispinosus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Pseudechiniscus sp. nov.[I]	-	-	-	-	1	-	-	2	-	-	-	-	-	-	-	-
Bertolanius weglarskae[S]	-	-	-	-	-	-	-	-	-	-	1	2	5	3	-	-
Diphascon pingue pingue	-	-	1	-	-	-	-	1	-	-	1	2	1	-	-	2
Diphascon pingue group sp.[I]	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Hypsibius cf. *convergens*[I]	1	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-
Hypsibius cf. *dujardini*	1	1	1	-	-	2	-	-	4	1	2	-	3	-	-	3
Hypsibius cf. *scabropygus*[I,S]	1	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-
Adropion belgicae[S]	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-
Adropion prorsirostre	-	-	-	-	-	-	-	-	-	-	4	-	4	-	-	7
Adropion scoticum scoticum	-	3	-	-	-	-	-	1	-	-	32	19	6	1	-	3
Astatumen trinacriae	-	-	-	-	-	-	-	-	-	-	5	-	3	-	-	1
Itaquascon cf. *globuliferum*[I]	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Mesocrista indet.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Pilatobius bullatus	2	-	-	-	1	-	-	4	-	-	-	-	-	-	-	-
Pilatobius ramazzottii[S]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-
Ramazzottius indet.	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
Isohypsibius prosostomus	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-	2
Dianea sattleri	6	-	-	1	1	3	-	11	4	1	-	-	-	-	-	-
Ursulinius sp. nov.[I]	-	1	2	1	-	-	-	-	-	-	-	-	-	-	-	-
Macrobiotus hufelandi group indet.	2	2	-	1	-	1	-	21	2	-	2	-	-	7	2	4
Mesobiotus harmsworthi group sp.	-	6	4	3	4	8	2	18	3	2	3	-	23	-	-	-
Minibiotus sp. nov.[I]	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-
Paramacrobiotus cf. *richtersi*	2	-	3	20	29	9	-	67	5	-	8	24	7	18	3	-
Murrayon hibernicus	-	-	-	-	-	-	-	E	-	-	-	-	-	-	-	-

Table 1. Systematical list of tardigrades, including encysted adults, collected from each sample. Locations: B1–10, Barna Woods, County Galway, Ireland; BH, Battle Hill, Huntly, Aberdeenshire, Scotland; FO, Fochabers, Winding Walks Wood, Morayshire, Scotland; IN, Invermorriston, Loch Ness, Highland, Scotland; LM, Lake of Menteith, Stirlingshire, Scotland; LH, Leith Hall, Kennethmont, Aberdeenshire, Scotland; SR, Slug Road, Stonehaven, Aberdeenshire, Scotland. E, egg only; **I**, new record for Ireland; **S**, new record for Scotland.

differs from that of *P. suillus sensu lato,* a clarified definition of that taxon is desired prior to any formal description of the collected specimens so that a complete suite of characters may be compared.

Class Eutardigrada Marcus, 1927
Order Eohypsibioidea Bertolani & Kristensen, 1987
Family Eohypsibiidae Bertolani & Kristensen, 1987

Bertolanius weglarskae (Dastych, 1972)
Scotland: Battle Hill, one cyst; Fochabers, two adults, three eggs; Invermoriston, one adult, four cysts, two eggs; Lake of Menteith, three adults, two eggs.
The adult (Fig. 1A,B) specimens and eggs conform to previous descriptions given by Dastych (1972) and Bertolani (1981) and to the illustrations and photomicrographs in Hansen *et al.* (2016), which also provides a key to the species of the genus. Morphometric values of selected characters of the Scottish specimens are given in Table 2.

Along with adults and eggs, five Type 2 cysts (Hansen & Katholm, 2002; Hansen *et al.*, 2016) were collected (Fig. 1C). These cysts, a dormancy life stage produced in response to adverse environmental conditions (see Bertolani *et al.*, 2019), varied in colour though were predominantly red or red-brown. In transmitted light, following mounting on slides in Hoyer's medium, all cysts appear brown.

B. weglarskae has been previously recorded from beech leaf litter in Italy by Guidetti *et al.* (1999) and Guidetti & Bertolani (2001). This is the first record of the species for Scotland.

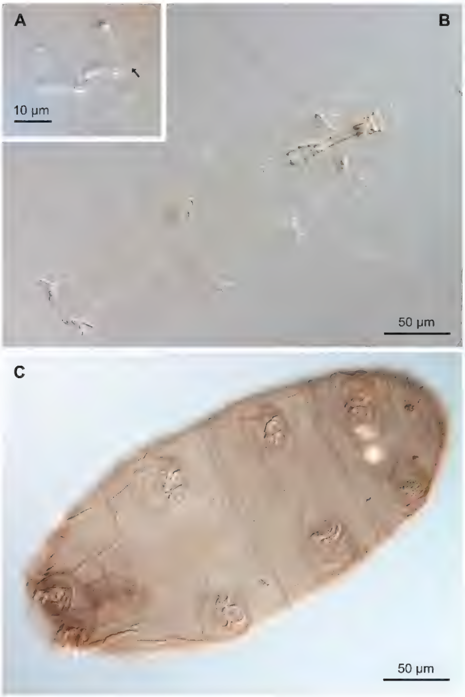

Fig. 1. *Bertolanius weglarskae* observed by differential interference contrast microscopy. (A) Claws on second leg pair. Black arrow indicates the cuticular bar positioned beside the internal double claw. (B) Habitus. (C) Type 2 cyst. (Photos: B. Blagden)

		µm			***pt***		
Character	**n**	**Range**	**Mean**	**SD**	**Range**	**Mean**	**SD**
Body length	6	269–638	443	148	685–1091	909	171
Buccal tube length	6	39.2–58.5	47.7	7.8	–	–	–
Stylet support insertion point	6	30.7–46.1	37.2	6.0	76.4–78.7	78	0.9
Buccal tube external width	6	5.3–8.9	6.8	1.4	13.1–15.2	14.1	0.8
Macroplacoid 1 length	6	6.2–10.8	8.4	2.0	15.5–19.3	17.5	1.5
Macroplacoid 2 length	6	5.4–10.2	8.0	1.9	13.8–19.2	16.6	2.2
Macroplacoid 3 length	6	6.3–13.9	10.3	2.6	16.0–25.1	21.5	3.2
Macroplacoid row length	6	20.9–37.2	29.3	6.4	53.2–67.1	61.0	5.0
External claw pair I primary branch length	6	10.3–18.3	14.7	3.4	26.3–33.4	30.4	3.2
External claw pair II primary branch length	6	11.1–20.6	16.5	3.6	28.3–37.5	34.3	3.2
External claw pair III primary branch length	6	13.1–21.1	17.3	3.8	32.1–41.3	35.9	3.7
Posterior claw pair IV primary branch length	6	15.4–27.8	21.4	5.0	39.2–48.1	44.5	4.0

Table 2. Selected morphometric data for Scottish *Bertolanius weglarskae* specimens. n, number of individuals measured; *pt*, *pt* index; SD, standard deviation.

Order Hypsibioidea Pilato, 1969
Family Hypsibiidae Pilato, 1969
Subfamily Diphasconinae Dastych, 1992

Diphascon pingue pingue (Marcus, 1936)
Ireland: Barna Woods: B3, one adult; B8, one adult.
Scotland: Battle Hill, one adult; Fochabers, two adults; Invermoriston, one adult; Slug Road, two adults.
Pilato & Binda (1997/1998; 1999) provided a detailed discussion of the *Diphascon pingue* group. This group of morphologically similar species comprises *Diphascon* Plate, 1888 that possess a smooth cuticle, three rod-shaped macroplacoids, microplacoid, and septulum and lack lunules or indentations of the claw bases and cuticular thickening on the legs (Fontoura & Pilato, 2007). All Irish and Scottish specimens (except one treated separately below) conform to the re-description of *D. pingue* by Pilato & Binda (1997/98). Identification of the specimens was confirmed through measurements of taxonomic characters according to Pilato & Binda (1997/1998; 1999). Qualitative and quantitative characters including the calculated *ptd* indices for measured structures fell within the species ranges given for *D. pingue* by Pilato & Binda (1997/1998; 1999). The specimens were also identifiable as *D. pingue* via the dichotomous key for the group by Fontoura & Pilato (2007). The collection of these specimens of *D. pingue pingue* from Barna Woods confirms the presence of the species in Ireland (see DeMilio *et al.* 2016).

"*Diphascon pingue*" has been recorded among several leaf litter types in many locations. These previous records include beech litter from the U.S.A. (Guidetti *et al*., 1999) and Italy (Guidetti & Bertolani, 2001) and various other litter types from the U.S.A. (Hinton & Meyer, 2007; Nelson & Bartels, 2007; Hinton *et al*., 2010; Hinton *et al*., 2014), Italy (Lisi, 2015; Roszkowska *et al*., 2019), Germany (Hohberg, 2006), New Guinea (Iharos, 1967, 1973) and Spain (Guil & Sánchez-Moreno, 2013). However, it is possible that some older records actually represent other similar species in the *pingue* group.

***Diphascon pingue* group sp.**
Ireland: Barna Woods: B9, one adult.
One specimen from Ireland belonging to the *Diphason pingue* group was determined to represent a separate taxon from the *D. pingue pingue* specimens detailed above. According to the key to the *pingue* group by Fontoura & Pilato (2007), this Irish *pingue* group specimen does not correspond well to a known species nor to species of the group described since the publication of that key (Kaczmarek *et al*., 2017a). Since some species of the *pingue* group are separated solely by quantitative differences and the collection of this single individual does not provide enough material for a complete set of morphometric data, the species identification is unresolved. However, the specimen clearly differs from those identified above as *D. pingue* by: the longer macroplacoids, the third of which is more than double the length of the equally long first and second, and the small appearance of the claws with short primary branches (claw pair I external primary branch = 4.7 µm, *ptd* = 34.4; internal primary branch, 3.8 µm, *ptd* = 27.8). Additional examples are required to identify this taxon more precisely, but it is counted as a new record for Ireland because only *D. pingue pingue* has been recorded from Ireland thus far, and the specimen clearly does not belong to that species.

Subfamily Hypsibiinae Pilato, 1969

Hypsibius* cf. *convergens (Urbanowicz, 1925)
Ireland: Barna Woods: B1, one adult; B8, two adults.
The three Irish specimens all possess a smooth, unpigmented cuticle and a buccal pharyngeal apparatus containing apophyses, two granular macroplacoids (macroplacoid 1 is longer than microplacoid 2), without microplacoid or septulum. Macroplacoid 1 has the form of an elongated granule with a subtle central constriction. Macroplacoid 2 lacks a constriction. For each of the mounted specimens, most claws were poorly oriented for obtaining a full set of morphometrics and observing structural details (no cuticular bars were observed).

The Irish specimens belong to the *H. convergens* group of species. The difficulties associated with identifications of *H. convergens* and close species have long been known (e.g. Bertolani 1982, Ramazzotti & Maucci, 1983), yet a complete modern re-description of the nominal species of the group is still lacking. When compared with the limited data given in the original description of *H. convergens*, the Irish specimens have a shorter body length (168, 173 and 190 µm) compared with the type (300 µm). Urbanowicz (1925) gave only one value, 10 µm, as the longest length measured for an external claw on an unspecified pair of legs. After calculating *pt* indices (Pilato, 1981) for the given claw measurement of the type of *H. convergens*, the *pt* value of 38.5 for the external claws (unknown pair) is slightly greater than that obtained for the Irish specimens' external claws where the mean *pt* value is 33.5 (those suitable for measurement on all leg pairs, n=4).

The Irish specimens were also compared with the actual type material and re-descriptions (Kaczmarek and Michalczyk, 2009) of the similar species *Hypsibius microps* Thulin, 1928 and *H. pallidus* Thulin, 1911 (NHMD catalogue numbers: TAR-000022, TAR-000023, TAR-000024, TAR-000025). These species also have smooth, unpigmented cuticles, two granular macroplacoids and lack the microplacoid and septulum. The Irish specimens clearly do not correspond to *H. microps*, most evidently because of the shorter, more granular microplacoid 1 of *H. microps*, along with differences in the *pt* values of measured structures. The mean *pt* values of some structures of the Irish specimens fall within the ranges for the type material of *H. pallidus* (body length, stylet support insertion point, microplacoid 2, and external buccal tube width). However, the Irish specimens do not have "*pallidus* type" claw morphology and according to the re-descriptions by Kaczmarek & Michalczyk (2009) neither *H. pallidus* nor *H. microps* has a constricted macroplacoid 1 as is evident in the Irish specimens. The description of another *convergens* group species, *H. pedrottii* Bertolani, Manicardi & Gibertoni, 1987, appears somewhat similar to the Irish specimens, particularly in terms of body length and placoid morphology, but *H. pedrottii* is distinguished from other *convergens* group species and the Irish specimens by its notably small claws.

"*Hypsibius convergens*" has been previously recorded from Italian beech litter (Guidetti *et al.*, 1999; Guidetti & Bertolani, 2001) and German leaf litter of several tree species (Hohberg, 2006). As a complete re-description of *H. convergens* from the type locality is necessary to understand the range of variability of the species and because the limited morphometric data that are given in the species description does not match exactly to that of the Irish specimens, open nomenclature is used for the identification of these individuals. This is the first record of the taxon for Ireland.

Hypsibius* cf. *dujardini (Doyère, 1840)
Ireland: Barna Woods: B1, one adult; B2, one adult; B3, one adult; B6, two adults; B9, four adults; B10, one adult.
Scotland: Battle Hill, two adults; Invermoriston, three adults; Slug Road, one adult.
H. dujardini belongs to a species complex, the *dujardini* group, that has long been regarded as cosmopolitan. Species of this complex exhibit a smooth, colourless cuticle and a pharynx containing two rod-shaped macroplacoids and septula. *Hypsibius dujardini* has been re-described using integrative methodology by Gąsiorek *et al.* (2018). In terms of qualitative characteristics, the Irish and Scottish specimens are in agreement with *H. dujardini sensu stricto* as determined by Gąsiorek *et al.* (2018). These traits include: a stout body form with smooth cuticle, eyes, a rounded pharynx containing prominent apophyses, two oval macroplacoids (the first has a central constriction under PhC and is longer than the second) and an obvious septulum. Additionally, cuticular bars are absent from leg pairs I-III. A short bar is present between the claws of leg pair IV that is close to, but not in full contact with the base of the posterior claw. The bases of the internal and anterior claws are broad. A lunule is observable on the anterior claw of some specimens but this is not definitively clear on all individuals.

DeMilio *et al.* (in press) collected *H. dujardini* from Clare Island, Co. Mayo and considered the species to be present in Ireland on the basis of morphological evidence. However, the subsequently published re-description of the species by Gąsiorek *et al.* (2018) includes a range of morphometric data for a neotype population, with which those authors suggest, all other records should be compared together with supporting molecular data whenever possible. Due to the suggestion by Gąsiorek *et al.* (2018) that cryptic species more morphologically similar to the type might be present in the *dujardini* complex, open nomenclature is used for the Irish and Scottish specimens pending the collection of more individuals for further morphometric and molecular studies in order to resolve the status of the species in these two countries.

The prolific records for "*Hypsibius dujardini*" suggest that the species group is common in a variety of leaf litters, including beech (Guil & Sánchez-Moreno, 2013), but the status of such records should be re-evaluated following the re-description by Gąsiorek *et al.* (2018).

Hypsibius* cf. *scabropygus Cuénot, 1929
Ireland: Barna Woods: B1, one adult.
Scotland: Battle Hill, three adults.
No morphological differences between the Irish (Fig. 2A) and Scottish examples were observed. All specimens match the original species description though this can be considered outdated in terms of modern standards. Cuénot (1929) did not specify the presence or absence of cuticular bars for the species, as this character was not commonly included in descriptions of the time. The present specimens all exhibit a short cuticular bar adjacent to the posterior claw of leg pair IV (Fig. 2B). The cuticular bars of the Irish and Scottish specimens appear identical to those seen on figures of specimens identified as *H.* cf. *scabropygus* by Zawierucha *et al.* (2014) from Latvia and Estonia and similar to those described by Ciobanu *et al.* (2014) on the same taxon reported from Romania. The former authors considered the possibilities that Cuénot and later authors (e.g. Ramazzotti & Maucci, 1983) could have missed the bars due to their small size or that specimens with bars represent a new species.

Guidetti & Bertolani (2001) recorded *H.* cf. *scabropygus* from leaf litter with a variation of the egg morphology. A close species, *H. stiliferus* Abe, 2004 described from eastern Russia, exhibits cuticular bars in a similar position to the Irish, Scottish, Baltic, and Romanian specimens. These observed variations, overlap in traits with similar species, and far-ranging geographical distribution records (McInnes, 1994; McInnes *et al.*, 2017) indicate the need for a modern re-description of the *H. scabropygus* in order to clarify the situation. This is the first record of the taxon for both Ireland and Scotland.

Subfamily Itaquasconinae Bartoš in Rudescu, 1964

Adropion belgicae (Richters, 1911)
Scotland: Invermoriston, two adults.
Both Scottish specimens conform to the brief description of the species by Richters (1911) based on material from Advent Bay and Hope Island, Spitsbergen, Svalbard. However, the original species description is insufficient by modern standards. Bernard (1977), recognised variation in later reports of the species by various authors from different localities and re-described the species. However, this was based on material from Michigan, U.S.A., not the original type location. Bernard (1977) suggested the possibility of the existence of a complex of similar species. This is particularly evident in the variation in the reports of the

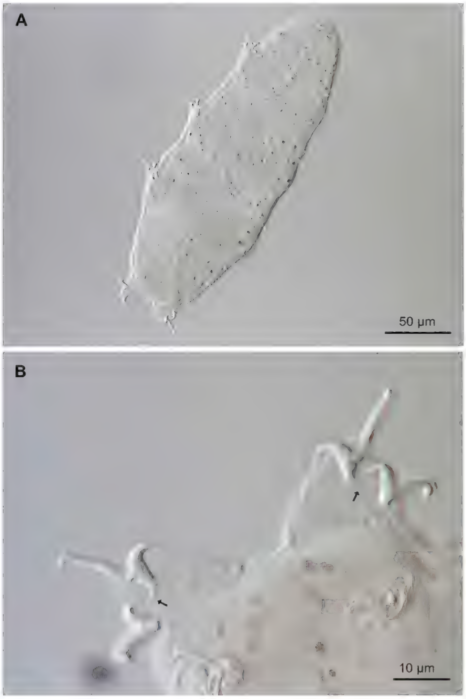

Fig. 2. *Hypsibius* cf. *scabropygus* observed by differential interference contrast microscopy. (A) Habitus. (B) Claws on fourth leg pair. Black arrows indicate the cuticular bar positioned between internal and external claw on each leg. (Photos: B. Blagden)

claw morphology. Richters (1911) described the claws as particularly unique in structure and appearing as the "*oberhauseri*" type, but did not state the presence or absence of associated cuticular bars. Pilato & Binda (1977) reported the presence of two cuticular bars on the claws of leg pairs I-III and a single bar on leg pair IV in their observations of specimens of *A. belgicae* from an unspecified location. Bernard's (1977) re-description also suggests the presence of cuticular bars associated with the claws of all leg pairs, although these differ in number and placement compared with those observed by Pilato & Binda. Dastych (1988) described Polish examples of *A. belgicae* that appear similar to the Scottish specimens in terms of placoid morphology and claw morphology.

The Scottish specimens have a smooth cuticle and lack eyespots. One individual (body length 400 µm) was suitable for selected measurements. The buccal tube external diameter is 2.5 µm and the total length of the buccal-pharyngeal tube is 30 µm. The pharynx contains two elongate rod-shaped macroplacoids, the first is approximately half the length of the second. In one specimen just one of the second macroplacoids appears fragmented at the middle of its length. Such fragmentation of the macroplacoids was also reported by Guidetti *et al.* (1999). Conspicuous, triangular microplacoids are present. The septulum is absent. Obvious cuticular bars are present on the first three pairs of legs and placed adjacent to the internal double claw. Cuticular bars are absent on the fourth pair of legs.

The Scottish specimens were also compared with *A. belgicae* from Austfjordnes, Svalbard present in the collection at the Natural History Museum of Denmark (catalogue number: TAR-002923 (processed by R.M.K.)). The museum specimen from Svalbard also corresponds well to Richters' description. The external claws have long and thin primary branches (22.8 µm on leg pair III for the branch alone, and 31.4 µm from branch tip to the claw base). The claws of the Austfjordnes specimen and the Scottish specimens have conspicuously broad basal sections (particularly on the external claws) and the internal divisions of the claw are as those observed by Dastych on the Polish specimens (Dastych, 1988: Fig. 120C). The presence or absence of cuticular bars could not be definitively confirmed for the Austfjordens specimen due to the condition of the cuticle.

It is possible that the descriptions by Bernard (1977) and Pilato & Binda (1977) correspond to closely related taxa within a species complex. *A. belgicae* requires formal re-description on material from the type location on Svalbard. Additionally, the results of molecular studies by Bertolani *et al.* (2014) suggest polyphyly of *Adropion* Pilato, 1987. Upon future evaluation of morphological and molecular data some *Adropion* species may be subjects of taxonomic rearrangement.

Specimens described as belonging to "*belgicae-scoticum* complex" were collected from beech leaf litter in the U.S.A and Italy (Guidetti *et al.*, 1999; Guidetti & Bertolani, 2001). *A. belgicae* was previously recorded from the leaf litter of several tree species in the U.S.A. (Nelson & Bartels, 2007). This is the first record of the species for Scotland.

Adropion prorsirostre (Thulin, 1928)
Scotland: Battle Hill, four adults; Invermoriston, four adults; Slug Road, seven adults.
The identification of the specimens was confirmed by comparison with the original type series of Thulin (1928), which consist of both Scottish and German examples (NHMD catalogue numbers: TAR-000776, TAR-000777).
Adropion prorsirostre has previously been recorded in beech leaf litter from Roan Mountain, U.S.A. (Guidetti *et al.*, 1999).

Adropion scoticum scoticum (Murray, 1905a)
Ireland: Barna Woods: B2, three adults; B8, one adult.
Scotland: Battle Hill, 32 adults; Fochabers, 19 adults; Invermoriston, 6 adults; Lake of Menteith, 1 adult; Slug Road, 3 adults.
All specimens conform to the original description by Murray (1905a), and are in agreement with the discussion of the species by Pilato (1974) and the subsequent account of British and Irish material of

Morgan & King (1976). Many of the larger specimens exhibit a light brown colouration of the cuticle.

This species has been recorded from "deciduous" and bracken (*Pteridium* spp.) leaf litter at Bookham Common, Surrey, England (Greaves, 1991; Greaves & Marley, 1994), beech leaf litter from Denmark (Hallas & Yeates, 1972) and the northern Apennines of Italy (Bertolani & Rebecchi, 1996), and from the litters of several tree species in various localities (Iharos 1967, 1973; Guil & Sánchez-Moreno, 2013).

Astatumen trinacriae (Arcidiacono, 1962)

Scotland: Battle Hill, five adults; Invermoriston, three adults; Slug Road, one adult.

The collected specimens correspond well to the original description of the species by Arcidiacono (1962). *A. trinacriae* has been previously recorded from beech leaf litter collected on Roan Mountain, U.S.A., and from the northern Apennines, Italy (Guidettti *et al.,* 1999; Guidetti & Bertolani, 2001). The North American and Italian populations were reported to differ by the presence of cuticular bars between the claws of all leg pairs only of the former population. Ciobanu & Kaczmarek (2012) recorded *A. trinacriae* from Romania that exhibit cuticular bars adjacent to the claws of legs pairs I-III. While the original species description does not specify either the presence or absence of cuticular bars, Ramazzotti & Maucci (1983) state that cuticular bars are present on either leg pair II or III and that Maucci observed an Italian population composed both of individuals with cuticular bars and those without bars. The Scottish specimens lack cuticular bars on all leg pairs. These observations of the variation of this character further support the suggestion by Kaczmarek & Roszkowska (2016) of the presence of a species complex associated with *A. trinacriae*.

Itaquascon* cf. *globuliferum Abe & Ito, 1994

Irish location: Barna Woods: B9, one adult.

Although only a single adult was obtained, the Irish specimen was determined to correspond closely to the original species description by Abe & Ito (1994). The cuticle is generally smooth but granulation is present dorsally and is arranged in faint, irregular elongated patches. Eyes are absent. The spiral thickenings of the flexible portion of the buccal-pharyngeal are only faintly visible with DIC, but are more evident with PhC. The pharyngeal bulb has a spherical appearance and contains placoids. Morphometrics of the Irish specimen for body length (204.4 µm), maximum body width (59.2 µm), length of buccal-pharyngeal tube (total length = 34.7 µm; rigid portion = 15.5 µm; flexible portion = 19.2 µm), external width of buccal tube (1.7 µm), length of bulb (17.3 µm), width of bulb (16.5 µm), length of placoids (5.1, 5.0, and 5.0 µm), are similar to those given for the type population (Abe & Ito, 1994) and result in closely comparable *pt* values. The stylet insertion point on the buccal tube was not recorded for the type population, but for the Irish specimen = 14.4 µm.

The morphology of the claws matches the description by Abe & Ito (1994) in having expanded bases without lunulae or dentition and two accessory points, but measurements were not provided for the type population. For the Irish example, the external primary branch height of the claw of leg pair I is 8.7 µm and that of the posterior claw of leg pair IV is 10.2 µm. The original species description states that cuticular bars associated with claws are not present. However, Guidetti *et al.* (1999) reported the presence of cuticular bars on all legs of specimens of *I. globuliferum* collected from Roan Mountain, Tennessee, U.S.A. The same authors also reported the presence of cuticular bars on leg pairs I-III of a paratype specimen they examined. The Irish specimen has clear cuticular bars on legs I-III adjacent to the internal claw base and between the claws of leg pair IV. Open nomenclature must be used for this specimen due to the presence of the bar on leg pair IV that was not included in the original description or in the report on the examination of the paratype by Guidetti *et al.* (1999).

In addition to the type population from Japan and the North American population reported by Guidetti *et al.* (1999), *I. globuliferum* was also reported from a second Japanese location by Ito & Abe (2001). This is the first record of the species and the genus from Ireland.

***Mesocrista* indet.**

Scotland: Slug Road, one adult.

Gąsiorek *et al.* (2016) revised *Mesocrista* and distinguished between *M. spitzbergensis* (Richters, 1903) and a new similar species, *M. revalata* Gąsiorek, Stec, Morek, Zawierucha, Kaczmarek, Lachowska-Cierlik & Michalczyk, 2016. Those authors concluded that previous records of *M. spitzbergensis* should be reconsidered as some may actually represent *M. revalata*. The Scottish *Mesocrista* specimen was not of satisfactory condition to allow for the distinction between these two taxa. "*Mesocrista spitzbergensis*" has been reported throughout the U.K. (e.g. Murray, 1905a; Greaves, 1991; Natress *et al.,* 2014) and from Kilsallah, Co. Mayo, Ireland (Le Gros, 1959). Le Gros' (1959) record lacks a description of the specimen so the status of the species in Ireland cannot be considered certain. Due to the poor quality of the Scottish specimen it was not possible to re-evaluate the status of these previous records of *M. spitzbergensis.*

Subfamily Pilatobiinae Bertolani, Guidetti, Marchioro, Altiero, Rebecchi & Cesari, 2014

Pilatobius bullatus (Murray, 1905a)

Ireland: Barna Woods: B1, two adults; B5, one adult; B8, four adults.

All specimens fit within the brief description by Murray (1905a) from the type locality at Loch Leven, Scotland. *P. bullatus* requires a formal re-description to include the modern taxonomic criteria because the original material probably does not exist (van der Land, 1966). Accounts of the species from Canada by Argue (1974) and Poland by Dastych (1988) provide greater detail than the original description, but these were based upon specimens collected at considerable distance from the *locus typus*. The Irish specimens are in particularly close agreement to the Polish examples of Dastych, having eight dorsal gibbosities arranged in two longitudinal rows, rounded or polygonal granulation (typically 1.1–2.2 µm in diameter) of the dorsal cuticle and gibbosities forming a vague mesh pattern, placoids of similar morphology and length, and stumpy claws with a cuticular bar present on the legs of pairs I-III and two cuticular bars on the legs of pair IV, each bar positioned laterally to each claw.

One specimen similarly matching the above-mentioned descriptions was also reported from moss on soil by Zawierucha *et al.* (2014) from Latvia. The species was previously recorded from beech leaf litter in Denmark (Hallas & Yeates, 1972) and Italy (Guidetti *et al.*, 1999) and from leaf litter in New Guinea (Iharos, 1973).

Pilatobius ramazzottii (Robotti, 1970)
Scotland: Leith Hall, four adults.
All specimens accord well with the description of the species by Robotti (1970) in terms of specific characters. These characters include: a finely granulated dorsal cuticle, pharyngeal bulb with prominent apophyses, two macroplacoids (centrally constricted macroplacoid 1 is longer than 2, macroplacoid 2 has a small caudal projection) and septulum, legs each with a bilobed gibbosity, and the presence of a cuticular bar originating from near the base of the internal claw on leg pairs I-III. While Robotti (1970) specifically stated that the species lacks accessory points on the claws, Pilato & Binda (1977) observed thin accessory points upon the examination of a paratype and refined the species description to include this trait. The Scottish specimens exhibit inconspicuous accessory points on the primary branches of all claws (visible at magnifications greater than x60). Structural measurements were chosen following Robotti (1970) for comparative purposes (Table 3). The original species description provided morphometrics for a single representative individual. The calculated *ptd* values for the data of the type specimen are close to those of the Scottish examples but the range of the morphometric data of the type population is unknown. Lisi *et al.* (2014) provided morphometric data for a paratype of *P. ramazzottii* to which the Scottish specimens were also compared in order to confirm the identification.

Pilatobius ramazzottii has been recorded from beech leaf litter from Italy and the U.S.A. (Guidetti *et al.*, 1999). This is the first record of the species for Scotland.

Family Ramazzottiidae Sands, McInnes, Marley, Goodall-Copestake, Convey & Linse, 2008

***Ramazzottius* indet.**
Scotland: Battle Hill, one adult.
Because species identifications within the genus *Ramazzottius* Binda & Pilato, 1986 typically require the observation of multiple adults and the egg (Biserov, 1997/98), a more precise identification of the Scottish specimens was not possible.

"*Ramazzottius oberhaeuseri*" (Doyère, 1840) has been recorded from leaf litter (Guidetti & Bertolani, 2001; Nelson & Bartels, 2007; Guil & Sánchez-Moreno, 2013). However, Stec *et al.* (2018) re-described *R. oberhaeuseri* and identified additional species forming a cryptic complex. Therefore, past records for '*Ramazzottius oberhauseri*' should be re-examined. Additionally, an unidentified *Ramazzottius* species was recorded in leaf litter from Texas (Hinton *et al.*, 2014).

		µm			***ptd***		
Character	**n**	**Range**	**Mean**	**SD**	**Range**	**Mean**	**SD**
Body length	4	289–355	317	28	1340–1840	1570	243
Buccal tube length	4	19.3–22.8	21.9	1.7	–	–	–
Pharyngeal tube length	4	46.0–55.1	48.9	4.4	200.6–285.2	242.8	41.8
Stylet support insertion point	4	13.7–16.9	15.0	1.4	63.9–74.4	68.6	5.0
Buccal tube internal width	4	1.4–1.8	1.6	0.2	6.6–8.9	7.7	1.0
Macroplacoid 1 length	4	5.3–7.1	6.5	0.8	28.9–36.8	32.0	3.4
Macroplacoid 2 length	4	4.2–5.4	4.8	0.5	20.6–27.9	23.5	3.4
Septulum length	4	2.3–2.8	2.6	0.2	9.9–13.9	12.9	2.3
External claw pair I primary branch length	2	11.4–14.0	12.7	1.8	50.1–72.5	61.3	15.8
External claw pair II primary branch length	3	12.8–14.3	13.5	0.8	62.7–79.2	69.4	8.7
External claw pair III primary branch length	2	12.9–13.9	13.4	0.7	56.6–82.1	69.4	18.0
Posterior claw pair IV primary branch length	4	13.1–15.2	13.5	1.6	57.6–78.7	66.5	9.1

Table 3. Selected morphometric data for Scottish *Pilatobius ramazzottii* specimens. n, number of individuals measured; *ptd*, *ptd* index; SD, standard deviation.

Order Isohypsibioidea Guil, Jørgensen & Kristensen, 2019
Family Isohypsibiidae Sands, McInnes, Marley, Goodall-Copestake, Convey & Linse, 2008

Isohypsibius prosostomus (Thulin, 1911)
Ireland: Barna Woods: B2, one adult; B8, one adult.
Scotland: Slug Road, two adults.
The identification of the specimens was confirmed by examination of the original type material (NHMD catalogue numbers: TAR-000662, TAR-000663) and description by Thulin (1911).

Previously the species has been recorded from Danish beech leaf litter (Hallas & Yeates, 1972) and from the litters of several tree species in Spain (Guil & Sánchez-Moreno, 2013).

Dianea sattleri (Richters, 1902)
Ireland: Barna Woods: B1, six adults; B4, one adult; B5, one adult; B6, three adults; B8, 11 adults; B9, four adults; B10, one adult.
All Irish specimens correspond to Dastych's (1991) re-description of the species (previously *Isohypsibius sattleri* Richters, 1902). Globally *Dianea sattleri* is a commonly recorded taxon but it likely represents a complex of similar species (Kaczmarek & Roszkowska, 2016). It has previously been recorded from Italian beech litter (Bertolani & Rebecchi, 1996), from leaf litter of New Guinea (Iharos, 1967) and from the litter of multiple tree species in Spain (Guil & Sánchez-Moreno, 2013).

***Ursulinius* sp. nov.**
Ireland: Barna Woods: B2, one adult; B3, two adults; B4, one adult.
The Irish specimens are similar in general appearance to *Ursulinius ronsisvallei* (Binda & Pilato, 1969), which was also described from beech litter (Italy) as *Isohypsibius ronsisvallei*. However, the conformation of the dorsal gibbosities differs from that of *U. ronsisvallei*, as well as from that of all other described species as determined by a comparison of all such species descriptions. The Irish specimens have: pigmented eye spots, two rod shaped macroplacoids, a partially reticulated cuticle with a unique arrangement of dorsal gibbosities in ten transverse rows (formula = [2-3-4-3-4-3-4-2-2-3]), two gibbosities on each leg, and a cuticular bar that is unlike that of *U. ronsisvallei* in terms of orientation with respect to the claws. This taxon will be described in a separate paper.

Order Macrobiotoidea Thulin, 1928
Family Macrobiotidae Thulin, 1928

***Macrobiotus hufelandi* group indet.**
Ireland: Barna Woods: B1, two adults; B2, two adults; B4, one adult; B6, one adult; B8, 21 adults; B9, two adults.
Scotland: Battle Hill, two adults; Lake of Menteith, seven adults; Leith Hall, two adults; Slug Road, four adults.
Precise identifications of taxa within this species complex typically require observation of the egg (Bertolani & Rebecchi, 1993). No eggs belonging to the "*hufelandi* group" were observed from the Irish or Scottish samples. As a result, the species level identity of the specimens was indeterminable. This taxonomically difficult group was reviewed by Kaczmarek & Michalczyk (2017). Following the updated criteria and terminology used for the group by those authors all adult specimens recovered from both Irish and Scottish leaf litter can be described as having *hufelandi* type oral cavity armature along with *hufelandi* type claws and smooth cuticles with pores. The number of *hufelandi* group species present among the samples could not be determined.

***Mesobiotus harmsworthi* group sp.**
Ireland: Barna Woods: B2, six adults; B3, four adults; B4, three adults; B5, four adults, four eggs; B6, eight adults; B7, two adults; B8, 18 adults, ten eggs; B9, three adults; B10, two adults
Scotland: Battle Hill, three adults; Invermoriston, 23 adults, nine eggs.
The adults of the Irish and Scottish populations are morphologically indistinguishable from each other and belong to the "*Mesobiotus harmsworthi* group". *Mesobiotus harmsworthi* (Murray, 1907) is the nominal species of a complex in which eggs are important for identifying taxa. *Mesobiotus harmsworthi harmsworthi* has been recently re-described by Kaczmarek *et al.* (2018). Those authors clarified the description of the egg morphology for *Mesobiotus harmsworthi*, which had become confused throughout previous decades of varying reports. While a total of 23 eggs was collected in the present survey, none of these matched well to the re-described *harmsworthi* egg or precisely to the descriptions of the eggs of any known species of the group. However, it could not be positively determined if the collected eggs fall within the range of variation for other *Mesobiotus* species that require modern re-descriptions, or if they represent a new species. For this reason, open nomenclature is used to designate the presence of at least one other *Mesobiotus* species in Scotland and Ireland that is not *M. h. harmsworthi*. This is not considered as a new taxon record for either country as the status of all records for the taxon made prior to the re-description are also reset to unidentified species of the *harmsworthi* group (Kaczmarek *et al.*, 2018).

***Minibiotus* sp. nov.**
Ireland: Barna Woods: B8, two adults.
Two specimens belonging to the genus *Minibiotus* R.O. Schuster, 1980 were retrieved from Barna Woods. These specimens possess 11 distinct transverse bands of round cuticular pores. The specimens are clearly different from *Minibiotus intermedius* (Plate, 1888), the only other species of the genus thus far recorded from Ireland and Scotland, which lacks cuticular pores entirely. The Irish specimens from Barna Woods could not be assigned a species identity from among the other known congeners most due to a unique combination of cuticular pore morphology and distribution, and the macroplacoid

length sequence. Morphologically similar specimens ascribable to this same taxon have been collected from another location in Scotland by one of the present authors. These have been determined to represent a new species, which is in the process of formal taxonomic description in collaboration with that author (B.B.) and another research group (Daniel Stec, pers. comm., November 2019).

Paramacrobiotus* cf. *richtersi (Murray, 1911a)
Ireland: Barna Woods: B1, two adults; B3, three adults, two eggs; B4, 20 adults, four eggs; B5, 29 adults, four eggs; B6, nine adults, two eggs; B8, 67 adults, 11 eggs; B9, five adults.
Scotland: Battle Hill, eight adults, 12 eggs; Fochabers, 24 adults; Invermoriston, seven adults, eight eggs; Lake of Menteith: 18 adults, five eggs; Leith Hall: three adults, two eggs.
Paramacrobiotus Guidetti, Schill, Bertolani, Dandekar & Wolf, 2009 has undergone recent revision (Kaczmarek *et al.*, 2017b; Marley *et al.*, 2018) with further detailed investigation of the *P. richtersi* complex and a re-description of the nominal species by Guidetti *et al.* (2019). *P. richtersi* (as "*Macrobiotus richtersi*") was described by Murray (1911a) from moss from Clare Island, Ireland. In his description Murray included an unnamed variety differing in the morphology of the egg. The eggs found among the Irish and Scottish beech litters exhibit internally sculpted areoles with reticulated processes and are of the "*richtersi* type" as defined by Kaczmarek *et al.* (2018). However, the collected eggs exhibit variation in several features. This variation, sometimes between the morphologies of processes on the same egg, complicated the species identification. Egg processes were observed with rounded and bluntly pointed cone shapes of varying dimensions (both width and height), with or without additional papillate structures at the cone apices, and varying in the number of processes per hemisphere. The adults of the Scottish and Irish populations are morphologically similar in the buccal armature and possess three macroplacoids and a microplacoid. However, various patterns of distribution of granulation on the leg pairs were observed.

Although *P. richtersi* has been recently re-described by Guidetti *et al.* (2019) and the specimens in the present study originate geographically near to the type locality, open nomenclature for these specimens is used pending a further study involving integrative molecular and morphological data in order to elucidate the extent of species richness within the *P. richtersi* complex in Ireland and Scotland.

Family Murrayidae Guidetti, Rebecchi & Bertolani, 2000

Murrayon hibernicus (Murray, 1911a)
Ireland: Barna Woods: B8, one egg.
A single egg conforming to the description given by Murray (1911a) of the type material from Achill Island, Ireland (Murray, 1911a) was collected. *Murrayon hibernicus* has not previously been recorded from leaf litter (Guil & Sánchez- Moreno, 2013), though an undescribed species of the genus was reported from leaf litter in Texas by Hinton *et al.* (2014).

DISCUSSION

The present study is the first report on the tardigrade species associated with the leaf litter microhabitat in Ireland and Scotland. Although the study was not intended as a quantitative ecological investigation, some new information concerning leaf litter-inhabiting tardigrades was gained. All samples were positive for tardigrades with the abundances of individuals being generally low (mean = 32 adult individuals per sample (N = 16)). Although few samples were included, several tardigrade taxa not previously known from these countries were recovered. In Ireland these were *Pseudechiniscus* sp. nov, *Diphascon pingue* group sp., *Hypsibius* cf. *convergens*, *Hypsibius* cf. *scabropygus*, *Itaquascon* cf. *globuliferum*, *Ursulinius* sp. nov., and *Minibiotus* sp. nov. The taxa newly discovered in Scotland were *Bertolanius weglarskae, Hypsibius* cf. *scabropygus*, *Adropion belgicae* and *Pilatobius ramazzottii. Itaquascon* cf. *globuliferum* and *Bertolanius weglarskae* represent the first records for their genera in the respective countries.

Thirteen of the 25 taxa collected in the present study required the use of open nomenclature. Of these, three taxa (of the genera *Pseudechiniscus*, *Ursulinius*, and *Minibiotus*) exhibited characters that separate each from the descriptions of any known species and were determined to represent new species, designated as sp. nov., to be described in separate papers. Open nomenclature was necessary for ten other taxa for various reasons: (1) the taxa exhibited a trait or traits not included in the original species description (*Hypsibius* cf. *convergens*, *Hypsibius* cf. *scabropygus, Itaquascon* cf. *globuliferum*); (2) the taxa belong to species complexes that require more data to make precise identifications than were collected (*Diphascon pingue* group sp., *Hypsibius* cf. *dujardini, Mesobiotus harmsworthi* group sp. and *Paramacrobiotus* cf. *richtersi.*); (3) species level identification was indeterminable because either eggs belonging to the taxa were not observed (*Ramazzottius* indet. and *Macrobiotus hufelandi* group indet.); or (4) the necessary characters for identification were not sufficiently preserved (*Mesocrista* indet.). This frequent employment of open nomenclature reflects a general change in tardigrade taxonomy in the modern era with the recognition of morphologically similar species complexes and cryptic taxa, many of which have been considered to be of cosmopolitan distribution in the past, and the need for integrative analysis to support identifications of such taxa (Gąsiorek *et al.*, 2018; Guidetti *et al.*, 2019). In such cases, a cautious approach is necessary when creating new species distribution records.

The species identities of some of the collected taxa could have been confirmed by the inclusion of molecular data, as some of these species have been recently re-described using integrative methodologies: *H. dujardini* (Gąsiorek *et al.*, 2018), *Mesocrista* spp. (Gąsiorek *et al.*, 2016), and *Paramacrobiotus richtersi* (Guidetti *et al.*, 2019). While some molecular data are available for the *Diphascon pingue*, *Ramazzottius oberhaeuseri*, *Macrobiotus hufelandi* and *Mesobiotus harmsworthi* groups (see e.g. Bertolani *et al.*, 2014; Stec *et al.*, 2018; Kaczmarek & Michalczyk, 2017; Kaczmarek *et al.*, 2018), sequences have not yet been obtained for many of the known species within these complexes, thus molecular data for the collected specimens belonging to these groups would not necessarily enable assignment to a known species or confirmation of new species status for the *Diphascon pingue* group sp. The resolution of the species identities of *H.* cf. *convergens*, *H.* cf. *scabropygus*, and *Itaquascon* cf. *globuliferum*, would be best facilitated by clarification of the morphological characters of the type populations via species re-descriptions or emendations.

There was some overlap in the collected taxa of the two countries with 8/25 found in both Irish and Scottish beech leaf litter (Table 1). Although *Mesocrista* spp. and *Murrayon hibernicus* have not been previously reported from leaf litter from any locality, Morgan (1980) reported "*Mesocrista spitzbergensis*" to be associated with soil collected in Iceland. Of the other taxa collected in the present study *Diphascon pingue pingue*, *Adropion belgicae*, *Adropion prorsirostre*, *Adropion scoticum scoticum*, *Astatumen trinacriae*, *Pilatobius bullatus*, *Isohypibius prosostomus*, *Dianea sattleri* and *Macrobiotus hufelandi* group sp. as well as the nominal taxa of species complexes *Hypsibius convergens* and *H. dujardini*, are also known to occur in European soils (Bingemer & Hohberg, 2017; and references therein). However, these taxa are also commonly collected from mosses and lichens and this may reflect generalist, rather than specialist, species ecologies.

In a study comparing richness and abundance of terrestrial tardigrades across multiple habitat types, Guil *et al.* (2009) found that leaf litter (along with mosses on rocks) contained exclusive species that did not occur in any of the other habitat types sampled. The recovery of at least three potentially new species and a total of 11 new distribution records for Ireland or Scotland from a small number of samples in the present study also indicates the importance of leaf litter as a microhabitat in determining the overall tardigrade biodiversity of an area. The new evaluation of extraction methods of tardigrades from leaf litter for quantitative studies by Czerneková *et al.* (2018) may be useful in facilitating more frequent inclusion of the leaf litter habitat in future ecological studies of tardigrades.

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Insects and arachnids of Ardeer, North Ayrshire, Scotland

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ABSTRACT

The Ardeer site on the Garnock Estuary in North Ayrshire, Scotland is considered to be the richest wildlife site in Ayrshire and to be of national significance. It has a rich and varied invertebrate fauna which reflects the wide range of habitats present ranging from sand dunes to wetland and woodland. This paper gives an account of some of the insects and arachnids that have been discovered there during recent surveys. A number of current threats are outlined.

INTRODUCTION

In a previous paper the insect fauna of the Ardeer area was mentioned as part of a wider review of sand dune sites in Ayrshire (Philp & Hamlin, 2016). Subsequent survey work has shown that the site is much richer than previously known and this paper outlines some new discoveries and discusses their importance, as well as providing greater detail on the importance of the whole site.

This importance has been thrust into greater prominence by recent media coverage outlining an anomaly in the planning system and the effect it is having on the site's biodiversity. In 1953 the U.K. Government passed a Special Development Order which effectively removed the requirement for planning permission for developments on the site. This has resulted in developments taking place that have bypassed the normal scrutiny of the planning process and have damaged the wildlife interest. Current "regeneration" proposals that could exploit this anomalous situation are being developed through the Ayrshire Growth Deal and threaten to cause further large-scale damage to the site.

HISTORY

The Ardeer site lies on either side of the estuary of the River Garnock, which is itself a SSSI, as it flows down towards Irvine, in North Ayrshire, Scotland (Fig. 1). The terrestrial part can be divided into four areas, one of which contains the core area of active industry and which has not been surveyed in any detail. The other three areas have been subject to ongoing survey work since 2010.

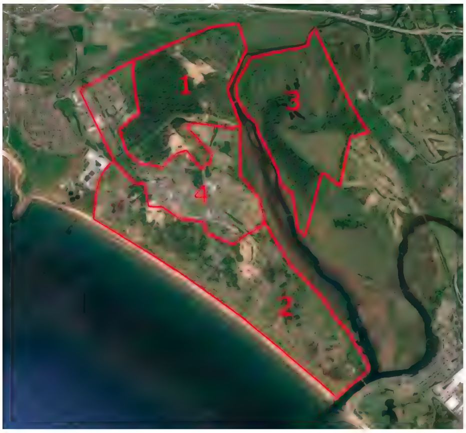

Fig. 1. Ardeer, North Ayshire, Scotland. Areas mentioned in the text: 1 – Garnock West (Black Powder Wood); 2 – Ardeer Peninsula; 3 – Garnock East; 4 – Industrial area. (Map data © 2019 Google)

Geological maps reveal almost all of the peninsula to be underlain by windblown sand. The earliest OS maps depict an extensive, largely undeveloped sand dune system, approximately 5 km in length and just over 2 km at its broadest (Ordnance Survey, 1856). Many of the sand dunes were over 15 m tall, with the tallest recorded being just over 27 m. Early references to "a sand desert" (Nobel, 1871, in Dolan & Oglethorpe, 1996) and an extensive plain that "exhibits a waste and dreary prospect of land, which blows in some places, and is prevented only by the deep-rooted bent growing through it, from being reduced to a dead level" (Woodrow, 1793) suggest a mobile dune system. Further evidence for the dynamism of the dunes comes from contemporary accounts of the sand covering crops and settlements further inland (Clements, 1974) and descriptions of the difficulty involved in stabilising the dunes during the late Victorian era (Trotter, 1938).

The earliest OS maps suggest saltmarsh covered extensive areas at the eastern edge of the peninsula, with some of the saltmarsh appearing to have been used as saltings (meadows subject to inundation by the sea). The more easterly area, marked on the map as Garnock East, has a long history of cultivation, with several farms being present at the site as far back as the earliest maps (Pont, in Blaeu, 1654).

The site changed dramatically in the years following 1871 as Alfred Nobel established and then built up his explosives works, eventually making it the largest explosives factory in the world. At its peak it employed around 13,000 workers and the site extended to over 500 ha. It was strategically important as a manufacturer of explosives during both World Wars and was a major employer in North Ayrshire. The company eventually became part of ICI and expanded its research and production to include artificial fibres, paints and many other products. Production declined throughout the late 20th century and the former factory now persists only as a small energetics factory employing a few hundred people (Dolan & Oglethorpe, 1996).

This very brief history appears to outline the familiar story of a natural habitat being replaced by a factory with a consequent loss of its wildlife value. However, in this case the relationship between industrial development and biodiversity is more complex. Although development destroyed significant areas of habitat, most of the buildings were, for safety reasons, spaced very far apart, leaving much habitat relatively intact. Furthermore, the exclusive use of the land as a factory effectively protected much of the site from golf and housing developments like those that have destroyed most of Ayrshire's other sand dune habitats. Furthermore, some industrial developments created new, interesting habitats. For example, the creation of fire ponds at Garnock East resulted in a 150 ha mosaic of wetland habitats, extensive tree planting created one of the largest woods in the county, and post-industrial remediation activities created large areas of bare sand and artificial dune slacks.

This all helped to diversify the range of habitats present and, following the closure of the site, most of the remaining land outwith the industrial estate has been largely left to develop without further disturbance.

However, the Special Development Order mentioned above has allowed large-scale sand quarrying at four locations in the north of the site, causing considerable damage (Fig. 2). As this has not required formal planning permission, there have not been impact assessments, or mitigation or restoration plans.

HABITATS

A broad range of "soft" coastal habitats is present at the southern part of Ardeer (the peninsula) ranging from sandy beach, embryo dunes, saltmarsh and mudflats through mobile dunes, fixed dunes, dune heath, dune slacks and dune scrub (Fig. 3). All of these have to some extent been altered by past and current management activities. For example, many of the tall fixed dunes are being targeted by the current quarrying operations and the extent of the mobile dunes is limited by the sea wall, although this is currently crumbling in places, especially at the southern end. The area supports the largest area of acid dune grassland in the U.K. (Dargie, 2000) and also one of the largest dune-spit systems (Dargie 1998).

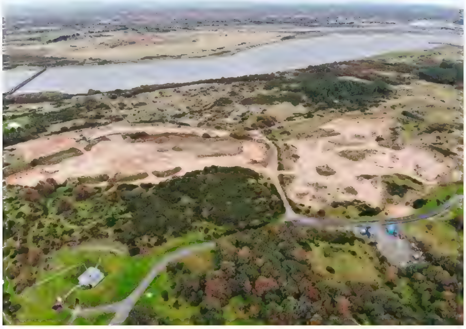

Fig. 2. Sand extraction in Garnock West, Ardeer, North Ayrshire, Scotland. (Photo: I. Hamlin)

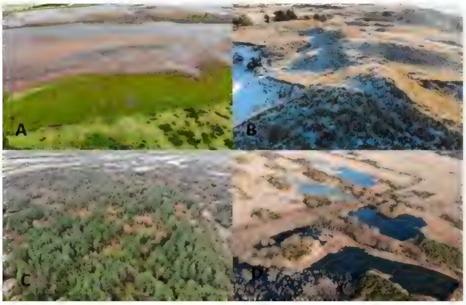

Fig. 3. Ardeer habitats, North Ayrshire, Scotland: A – Saltmarsh; B – Fixed dunes; C – Black Powder Wood (Garnock West); D – Garnock East. (Photos: I. Hamlin)

All of these habitats have to some extent been altered by past and current management activities. For example, industrial earthworks reshaped dunes into tall blast walls and embankments, providing many areas of dune grassland with a hot, calm microclimate ideal for thermophilic invertebrates. Industrial excavations down to the water table created a diverse array of freshwater wetlands across the peninsula: dune slacks, swamp, marshy grassland, ephemeral pools and large, well-vegetated ponds with much open water.

The Ardeer site is also one of the most heavily wooded areas in North Ayrshire. It supports numerous large, over-mature conifer plantations which were planted in the mid 20th century and consist mainly of Corsican pine (*Pinus nigra*). They have been subject to little recent management and consequently contain significant amounts of dead wood. Over the decades, broadleaved species have colonised and the pines are, in places, greatly outnumbered by birches (*Betula* spp.), willows (*Salix* spp.), alder (*Alnus glutinosa*) and sycamore (*Acer pseudoplatanus*). Outside of the pine plantations, numerous areas of semi-natural woodland have established. In total, the peninsula supports over 100 ha of woodland.

The Garnock East portion of the site is quite different. Here the site is dominated by an extensive mosaic of fen, swamp, open water, scrub and woodland. The coastal influence is still evident with small areas of saltmarsh lining the western fringe of the site and relict areas of dune heath surviving in the east on ancient windblown sand deposits.

There is very little information about the wildlife of the site during its industrial period. Explosives works are inherently dangerous and access was not allowed while the site was in operation. With no tradition of visiting the site, it was used very little by the local population and, apart from visits by birdwatchers to the mudflats, no wildlife surveys were conducted.

From around 2009 I.H. started to look at the Hymenoptera on the site and it became clear that as well as several interesting and uncommon species being present, other groups such as hoverflies and beetles were well represented. Since then there has been more intensive survey work, which has reinforced the belief that Ardeer is of considerable importance for its invertebrate fauna.

Over the past ten years the survey effort has increased. In 2014 Buglife carried out a general survey of parts of Garnock West (Shanks, 2014) and since then both I.H. and B.P. have been involved in more intensive surveys of various parts of the site. Most of this work has focused on Coleoptera and Hymenoptera, although other groups such as spiders and syrphids have been recorded at the same time. Further work has involved Butterfly Conservation, Buglife and individual surveyors. A wide range of survey methodologies has been employed here including general searching, pitfall trapping, sweep and "pond" netting, and pan, light and interception trapping, so that the resulting species list should give a good representation of what species are present.

A summary of the overall results to date is shown in Table 1. Only species whose conservation status is recognised as Red Data Book, Nationally Rare/Scarce or Nationally Notable (NA/NB) are included in the third column. The rarity statuses in different groups have been updated at a national level at different times and are not directly comparable. More general information on distribution, although to some extent subjective, has been obtained from the NBN Atlas, from local knowledge and from group specific publications and websites (e.g. www.bwars.com).

INSECTA

Coleoptera

With over 340 species of beetles having been recorded, Ardeer is the richest site for Coleoptera in Ayrshire. Given the wide range of habitats present, a correspondingly wide range of beetles would be expected.

Insect group	Species recorded	Rare/Scarce species
Coleoptera	341	22
Lepidoptera	216	4
Hymenoptera	132	3
Diptera	124	3
Araneae	103	4

Table 1. Number of species of insects and arachnids recorded at Ardeer, North Ayrshire, Scotland, and the number whose conservation status is designated as Red Data Book, Nationally Rare/Scarce or Nationally Notable (NA/NB).

It is worthwhile looking at broad habitat types and highlighting those species that are recognised as rare or threatened at a UK level. It is important to note, however, that many species are significant because they are scarce in Scotland or because Ardeer represents an extension or new limit to their range.

Coastal

Ardeer supports two Nationally Rare sand dune specialists - *Hypocaccus rugiceps* and *Orthocerus clavicornis* (hairy-horned sand beetle) - and also boasts a first Scottish record for the Nationally Scarce carabid *Harpalus neglectus* (Philp & Hamlin, 2018). Three other, more widespread dune species are the minotaur beetle *Typhaeus typhoeus* (Fig. 4) (Philp, 2018), the tenebrionid *Phylan gibbus* and *Aegialia arenaria* (dune chafer). These are fairly widespread in England and Wales but are much less common in Scotland with Ardeer being at the northern limit for the first two.

The estuary of the River Garnock has an area of SSSI saltmarsh and mud flats where two Nationally Scarce species occur: *Phaedon concinnus*, here near its northern limit, and *Dyschirius politus*.

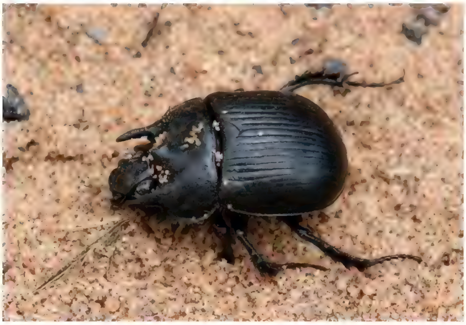

Fig. 4. Minotaur beetle (*Typhaeus typhoeus*) on Ardeer Peninsula, North Ayrshire, Scotland. (Photo: I. Hamlin)

Grassland and Heath

The dunes blend into fixed grassland and dune heath where *T. typhoeus* can still be found along with the ladybird *Coccinella hieroglyphica*, and then into permanent grassland further from the shore. Beetles of note here include *Oedemera virescens* (Nationally Rare), *Tropiphorus terricola* and *Barynotus squamosus* (both Notable B), *Cassida nobilis* (Nationally Scarce) and *Olibrus aeneus*, which is scarce in Scotland. All the grassland shows the influence of the sandy substrate, so that even fairly far from the shore species such as the weevil *Andrion regensteinense* are frequent.

Wetland

Ardeer has a range of wetland types from dune slacks through seasonal wetlands in former sand quarries to permanent wetland around the open water in Garnock West and East. A fairly large seasonally flooded former sand extraction area on the peninsula has a silty bottom and several specimens of the Nationally Scarce *Stenolophus mixtus* were found, the second site for the species in Scotland, and the furthest north. Also in this area were *Blethisa multipunctata* (Nationally Scarce), *Gabrius osseticus* (Notable B) and *Agonum emarginatum*, a scarce Scottish species.

Other areas of wetland support weevils such as the Notable B *Grypus equiseti* and *Tournotaris bimaculatus*, the latter being very scarce in Scotland. There is considerable scope for more detailed survey work in the extensive Garnock East area.

Open Water

There are large areas of open water on both sides of the River Garnock as a result of past industrial activity. Some of these ponds are well vegetated and hold water beetles nearing their northern limits such as *Noterus clavicornis* and *Enochrus testaceus*. As well as the truly aquatic species there are others that live in close association with water such as *Donacia vulgaris*, *Limnobaris dolorosa*, *Scirtes hemisphaericus* and *Galerucella sagittariae*.

In other areas there is more fen-like vegetation with *Sphagnum* spp. present. Among the commoner species here were a number of specimens of *Nartus* (formerly *Rhantus*) *graptii*. This is the second Scottish record for the species.

Woodland

Much of the woodland sampling has been in the pine plantations and this is reflected in the species list. The weevil *Magdalis duplicata* (Notable A) is a native pinewood specialist with only a few records outside its core range (Philp, 2017). Other pine specialists of note include the first Scottish record of the naturalised immigrant red longhorn beetle *Stictoleptura rubra*, the uncommon 18-spot ladybird (*Myrra octodecimguttata*) and the striped ladybird (*Myzia oblongoguttata*).

A number of saproxylic beetles have also been found. None has any national conservation status, but several are very local or scarce in Scotland. These include the sap feeders *Omosita depressa* and *Soronia punctatissima*, fungus feeders such as *Dacne bipustulata*, *Sphaeriestes castaneus* and *Cis boleti*, and wood borers such as *Ptilinus pectinicornis* (fan-bearing wood borer), *Hylurgops palliatus*, *Hylastes brunneus* and the introduced *Euophryum confine*.

Hymenoptera

Although the "Parasitica" and Symphyta have received little recording effort, significant attention has been paid to the aculeate hymenopterans on the peninsula. In large part because of its sandy substrate and bountiful supply of wildflowers, the site has the most diverse assemblage of bees and wasps in Scotland - 113 species.

Coastal

The peninsula is home to several coastal specialists. *Colletes floralis*, a pRDB species (likely to appear in the Red Data Book) associated with machair and sand dunes, is found commonly across much of the site. On the Ayrshire coast, *C. floralis* is kleptoparasitised by the cuckoo bee *Epeolus cruciger*. Scotland's first official record of *E. cruciger* pertains to a male caught nectaring on wild thyme (*Thymus polytrichus*) on the peninsula in July 2013.

Colletes fodiens is known only in Scotland from the Ardeer area and Torrs Warren on the Solway coast. A very few discrete populations are dotted around the peninsula where there is an abundance of open sand and its forage source - ragwort (*Senecio jacobaea*) - is present in good quantities.

Other uncommon coastal specialists include the wasp *Dryudella pinguis* and the Nationally Scarce wasp *Oxybelus mandibularis*, which, along with the commoner *O. uniglumis*, is at the northern limit of its U.K. range at Ardeer.

The peninsula has several species now largely restricted to the coast following major declines inland, presumably as a result of the loss of wildflower-rich grasslands. These include the leaf-cutter bee *Megachile circumcincta*, and the mason wasp *Ancistrocerus scoticus* and its cuckoo *Chrysis rutiliventris*.

The site also supports several species that, although relatively widespread in England and Wales, are local and coastal in Scotland. These include the digger wasps *Crabro peltarius* and *Tachysphex pompiliformis* and the spider-hunting wasp *Pompilus cinereus*, all of which are on the Scottish Biodiversity List.

Grassland and heath

The peninsula supports a very diverse assemblage of aculeates associated with sandy grassland. Several rare wasp species have been recorded. A female *Priocnemis schioedtei* caught on a sandy track is one of the very few Scottish records of this Nationally Scarce spider-hunter. Similarly, a male *Odynerus spinipes* found in the same area represents the first modern Scottish record. Sandy pools at the site have produced several records of *Anoplius concinnus*, a wasp ecologically unusual in its association with wet areas, where it hunts wetland wolf spiders. Reflecting the abundance of spider-hunting wasps, the rare cuckoo spider-hunter *Ceropales maculata* has been recorded several times.

The large cuckoo bee *Nomada flava* was added to the site list in 2019. This appears to be the second Scottish record, following one caught at Carbarns, Lanarkshire in 2018 (Weddle, 2019). Other uncommon solitary bee species include the northernmost confirmed records of *Lasioglossum fulvicorne* and *L. punctatissimum*, and three species of yellow-faced bee: *Hylaeus hyalinatus* (Fig. 5), *H. confusus and H. brevicornis*.

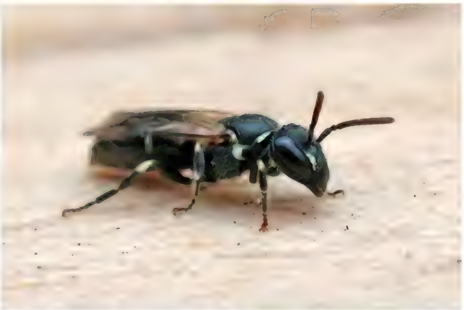

Fig. 5. Female yellow-faced bee *Hylaeus hyalinatus*. (Photo: I. Hamlin)

The extensive areas of dune heath at the site support an assemblage of local heathland bees, including *Bombus jonellus*, *Colletes succinctus* and *Andrena fuscipes*.

Woodland
Many of the species encountered in the peninsula's extensive woods do not have an ecological association with woodland, but simply make use of the sheltered, sandy tracks and clearings in the woods for nesting and foraging. However, several species rely on the woodland component of the site for breeding and feeding. The bountiful supply of deadwood throughout the wood provides ample nesting opportunities for solitary wasps. These include the Nationally Scarce *Ectemnius ruficornis* and *Crossocerus leucostomus*, both of which have a strong association with dead pine. The latter species was added to the site list in May 2018, when three males were found patrolling a fallen pine trunk.

The numerous willows (*Salix* spp.) that line the woodland edge and woodland tracks are an important foraging resource for several early solitary bees, including the RDB3 mining bee, *Andrena ruficrus*. Another uncommon "northern" mining bee - *A. coitana* - has been recorded at the site several times. It similarly displays a preference for scrubby woodland edge, where, amongst the tangle of bramble (*Rubus fruticosus* agg.) and small trees, it forages on thistles (*Cirsium* spp.) and knapweed (*Centaurea nigra*).

Lepidoptera
A total of 219 species of butterflies and moths has been recorded on the Ardeer Peninsula. Despite relatively little recording of moths having taken place, all the site's main habitat types have been surveyed.

Coastal
Some of the site's rarest moths are coastal specialists. Ayrshire's first record of the Nationally Scarce shore wainscot (*Mythimna litoralis*) pertains to two specimens caught on the peninsula in July 2018. Similarly, Ayrshire's first coast dart (*Euxoa cursoria*), another Nationally Scarce species, was trapped in dune heath several years earlier. Three local, coastal species abundant at the site are archer's dart (*Agrotis vestigialis*), white-line dart (*Euxoa tritici*) and straw underwing (*Thalpophila matura*). The last species, although widespread in England, has a patchy coastal distribution in Scotland. It is often the most abundant moth to be found in the seaward dunes in mid-summer.

The peninsula is the main Ayrshire site for dog's tooth (*Lacanobia suasa*), a species with a strong affinity for saltmarsh. All Ayrshire records come from the Ardeer area, most likely because the Garnock Estuary supports the only significant area of saltmarsh in the county.

Grayling (*Hipparchia semele*), a declining coastal butterfly, is present in large numbers throughout most of the site, especially where there are significant patches of open sandy ground and overgrown brownfield areas.

Grassland and Heath
In mid-summer, the peninsula's acid grassland is covered in a carpet of wild thyme. It is the only known Ayrshire site for the Nationally Scarce thyme pug (*Eupithecia distinctaria*). The local and declining hedge rustic (*Tholera cespitis*) has also been recorded several times.

Several uncommon grassland micro moths are present at the site, including the burdock conch (*Aethes rubigana*), *Teleiopsis diffinis* and *Pancalia schwarzella*. The Ardeer Peninsula is the only known Ayrshire site for the latter two species.

The peninsula supports the largest colony of dark green fritillary butterfly (*Argynnis aglaja*: Fig. 6) in North Ayrshire: dozens are on the wing in July. Small pearl-bordered fritillary (*Boloria selene*) has been encountered at the site, although a colony has yet to be discovered.

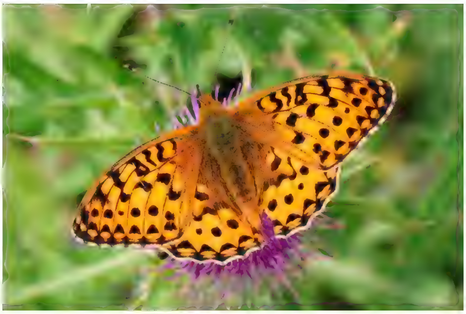

Fig. 6. Dark green fritillary (*Argynnis aglaja*). (Photo: I. Hamlin)

The dune heath provides habitat for several uncommon heathland moths, including the anomalous (*Stilbia* *anomala*), heath rustic (*Xestia agathina*) and beautiful yellow underwing (*Anarta myrtilli*).

Wetland
Although the site's wetland habitats have received relatively little recording attention, several interesting wetland species have been found. These include the Nationally Scarce macro moth, marsh oblique-barred (*Hypenodes humidalis*) and the local micros beautiful china mark (*Nymphula nitidulata*) and shy cosmet moth (*Limnaecia phragmitella*).

Woodland
The peninsula's woodlands support an interesting assemblage of local species. Small yellow wave (*Hydrelia flammeolaria*), a scarce moth in Scotland, has been recorded twice on the peninsula. It is not clear which of its two main foodplants, sycamore and alder, it is utilising at the site. During the summer of 2019, a single scallop shell (*Rheumaptera undulata*), another local woodland specialist, was disturbed during the day from a wetland complex in the Black Powder Wood, where its foodplant, willow, grows in abundance. Other local woodland species include dark spectacle (*Abrostola triplasia*), scorched wing (*Plagodis dolabraria*), green silver-lines (*Pseudoips prasinana*) and the micro moth *Carcina quercana*.

A number of local moths associated with scrub have also been recorded. The Nationally Scarce broom-tip (*Chesias rufata*) is common in the extensive stretches of broom (*Cytisus scoparius*). Similarly, July belle (*Scotopteryx luridata*), a local gorse (*Ulex europaeus*) and broom feeder, has been found several times. Grass emerald (*Pseudoterpna pruinata*) and Chinese character (*Cilix glaucata*), two species largely restricted to the southwest are present in scrubby areas where their foodplants, gorse and hawthorn (*Crataegus monogyna*) and bramble respectively, are found. The local green longhorn moth *Adela reaumurella* has been observed in flight around woodland edge shrubs.

Diptera

Relatively little recording of Diptera has taken place at Ardeer. Data from two Buglife invertebrate surveys have been supplemented by other casual recording distributed across much of the rest of the site, leading to a site list totalling 124 species.

Coastal
Two Nationally Scarce sand dune specialists have been recorded. The sand dune hoverfly *Eumerus sabulonum* (Fig. 7) is commonly encountered at the site. In Britain its distribution is restricted to the west coast between Cornwall and Ayrshire. *Phthiria pulicaria* (flea bee-fly) can be locally abundant on yellow composites, such as hawkweeds (*Hieracium* spp.), in the dunes.

Other local coastal flies include the shore fly *Philygria punctatonervosa*, the sciomyzoid *Heterocheila buccata*, the muscid *Helina protuberans*, the satellite fly *Senotainia conica* and the robberfly *Philonicus albiceps*. The last two species are towards the northern limit of their British range at Ardeer.

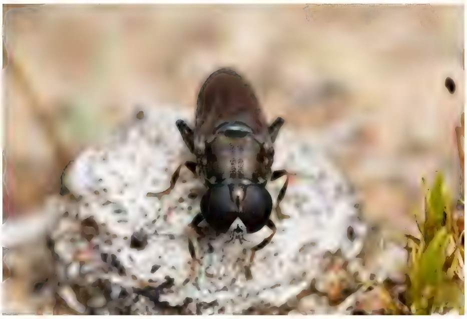

Fig. 7. The sand dune hoverfly *Eumerus sabulonum*. (Photo: I. Hamlin)

Grassland and Heath
The Nationally Scarce stilt-legged fly *Micropeza lateralis* has been found in scrubby acid dune grassland. Other local grassland species include the tachinid *Appendicia truncata* and *Dysmachus trigonus* (fan-bristled robberfly). The latter species is particularly common at the site. The gall fly *Tephritis formosa* has a restricted range in Scotland and is near the northern limit of its British range at Ardeer.

Woodland
The woodland habitats at the site are some of the least studied, both in terms of flies and invertebrates more generally. However, the scarce deadwood hoverfly *Criorhina ranunculi* has been caught around sallow blossom in early spring, and the local hoverfly *Chrysotoxum festivum* has been encountered several times, especially where open areas are starting to be colonised by young birch. *Nilea hortulana*, a tachinid towards the northern limit of its range at Ardeer, has been recorded at the site.

ARACHNIDA

Araneae

Spiders at the Ardeer site have until recently received little attention, with nearby coastal sites such as Gailes and Shewalton being better known. The only known investigation before the present series was by staff of Glasgow Museums in 1988, who concentrated on the fixed dunes. Spiders were collected and identified by Dave Beaumont (pers. comm.). The 16 species found in 1988 are included here. Amongst these was then the first record for Scotland of the bridge orbweb spider *Larinioides sclopetarius*. More recently there have been collections by Buglife (Shanks, 2014), by B.P. in 2018 and 2019, and I.H. in 2019. The last two large collections were identified by A.L. The bulk of the recent sampling has been made using pitfall trapping, but the early records and some of the recent ones are based on hand collection. Pitfall trapping biases the collection in favour of ground-living active spiders, at the expense of species living higher in the vegetation column.

Ninety one species of spiders have been found at Ardeer, five with national rarity designations, making it the second most species-rich site in Ayrshire after the Dalmellington/Sillyhole Moss complex sampled by Dave Curtis and students in 1977, where 92 species were recorded, 11 with national designations (Spider Recording Scheme, 2019; Curtis, 1977).

The spider community at Ardeer is dominated by members of the Lycosidae (wolf spiders), active hunters of open areas. Of the 30 species of Lycosidae found in Scotland, at least 15 have been found here. While pitfall trapping can overemphasise the importance of active hunters, the dominance of the group at 87% of the total catch and their large size indicate an ecosystem in which wolf spiders play the key role.

Coastal

Most of the spider interest of the site is in the coastal assemblages. The saltmarshes are dominated by the lycosid *Pardosa purbeckensis*, a species confined to the habitat. The Nationally Scarce sac-spider *Cheiracanthium virescens* is also confined to this habitat at Ardeer, though it is more usually found in dunes and heath. Three widespread species of lycosid - *Pardosa monticola*, *Alopecosa pulverulenta* and *Trochosa ruricola* - are found in this hostile habitat, along with small numbers of highly mobile Linyphiidae (money spiders) including *Oedothorax fuscus* and *Erigone longipalpis*, a species often found in saltmarshes.

Inshore from the saltmarsh, open sand and mobile dunes have a characteristic community dominated by the Nationally Scarce and southern *Xerolycosa miniata* and with *Arctosa perita*, both sand specialists. *X. miniata* (Fig. 8) has only one previous Ayrshire record, having been identified by the Glasgow naturalist Henry Young from spiders collected at Prestwick by F. Alexander in 1878, the first record of the species for Scotland (Young, 1879). The species is abundant here and this is the northernmost site on the west coast of the U.K., though it is found as far north as Angus on the east coast.

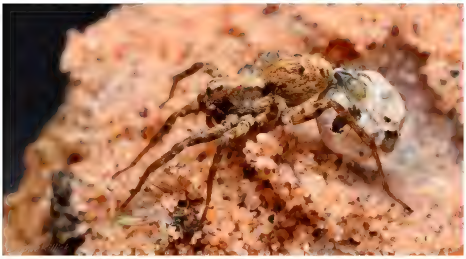

Fig. 8. The dune wolf-spider *Xerolycosa miniata.* (Photo: T. Killick)

Dunes dominated by marram grass (*Ammophila arenaria*) have large numbers of the Nationally Scarce *Pardosa agrestis.* The Nationally Scarce *Scotina gracilipes* was found in an open sand area, while the 1997 record for the characteristically southern species of orb web spider *Hyposinga pygmaea* was from fixed dunes, as was the 2018 record for the Nationally Scarce linyphiid *Agyneta* (formerly *Meioneta*) *mossica.*

Fixed dunes and dune slacks have a rich spider community, with more widespread lycosids such as *Pardosa amentata*, *P. nigriceps* and *Pirata piraticus* dominant. The orb web spinner, *Agalenatea redii* was found in dune slacks at its new northernmost site in the U.K. *Walckenaeria unicornis*, a mainly southern money spider (Linyphiidae), is one of several species of money spider found on Ardeer fixed dunes.

Ardeer is a striking example of a near complete set of spider communities characteristic of the gradient from sand and saltmarsh through dune habitats to heath, grassland and wetland.

Grassland and heath

Dune heath is home *to Alopecosa barbipes*, a species more typical of south coast heathland. The linyphiid *Walckenaeria atrotibialis*, a southern species of heath and calcareous grassland also occurs on Ardeer dune heath. Two large species of ground spiders (Gnaphosidae) - *Drassodes cupreus* and *Haplodrassus signifier* - while found in a range of Ardeer habitats, are commonest on dune heath. The distinctive gnaphosid *Drassyllus pusillus* was found in all coastal sites including saltmarsh and bare sand. In east Scotland and southern England this species is found in heathland and dry grassland, with related *Drassyllus* and *Zelotes* species in the more maritime habitats. None of the other species in this group has been found at Ardeer.

Dune grassland and improved pastures are dominated by the widespread lycosids *Pardosa agrestis, P. pullata* and *Alopecosa pulverulenta*, but it is also the habitat favoured by four species of crab spider (Thomisidae): *Ozyptila trux*, *Xysticus cristatus*, *X. erraticus* and the southern heathland species *X. audax.*

Wetland

Wetlands have not been well sampled, but the *Typha* swamp that was investigated was dominated by lycosids typical of wet habitats, including the characteristic pair *Pardosa pullata* and *Pirata piraticus*. Open water sites have not been sampled for spiders.

Woodland

A pine wood was the only woodland habitat that was sampled. Very few spiders were taken, though it contributed to the species list by providing the only records for some very widespread species, such as the near-ubiquitous linyphiids *Tenuiphantes alacris* and *T. zimmermannii*. No Lycosidae were found in the woodland.

Five species found at Ardeer are Nationally Scarce (Harvey *et al.*, 2018). A high percentage of species (16.5%, i.e. 15/91) have characteristically southern distributions, in several cases at or near their most northerly U.K. site. A significant number of species are normally associated with southern heathland.

Opiliones

Ten species of harvestmen were found at Ardeer out of the total of 21 Scottish species. These include two new to Ayrshire: *Mitostoma chrysomelas* and *Lacinius ephippiatus*. All of the harvestman species found here are widespread and not considered to be of conservation concern.

DISCUSSION

In terms of its extent and variety, the suite of habitats present at Ardeer is unique in Ayrshire and probably in Scotland. The complex history of management on the site has meant that many of the original sand dune species, such as the hairy-horned sand beetle (*Orthocerus clavicornis*), the sand dune hoverfly *Eumerus sabulonum* and the northern colletes *Colletes floralis*, have survived. Furthermore, over a century of industrial interventions has brought in a wide range of new species and these reflect the wide variety of habitats: from unusual varieties of dune heath to huge areas of mixed and native woodland, and to complex wetland mosaics.

This diversity would be enough to highlight the importance of the site, but Ardeer's geographical location also makes it noteworthy. Ardeer is on the relatively sheltered and mild Clyde estuary and represents the northernmost large dune complex on the west coast mainland. Because of this, the site marks the northern limit for many species that have a southern distribution (e.g. the tenebrionid beetle *Phylan gibbus*, the yellow-faced bee *Hylaeus brevicornis*, and the gorse orb-weaver *Agalenatea redii*) and a very restricted distribution in Scotland. Crowson (1963) commented on the presence of southern species on the Solway and Ayrshire coasts, a fact which he thought had been previously overlooked.

The threats posed by the Special Development Order (SDO) and the Ayrshire Growth Deal are significant and made more so by the lack of any formal recognition of the site's importance. North Ayrshire Council has so far failed to add Ardeer to the list of Local Nature Conservation Sites in their Local Development Plan and Scottish Natural Heritage cannot consider the site for designation because of the SDO. A local Action Group, led by the Scottish Wildlife Trust but including Buglife, Butterfly Conservation, Plantlife and RSPB, has been set up to highlight the site's importance, to try to get the SDO revoked, and to ensure that any plans proposed as part of the Growth Deal are subject to a full Strategic Environmental Assessment.

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Soils and earthworms as a final chapter in the narrative of a steelworks

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ABSTRACT

Hallside steelworks, South Lanarkshire, Scotland, employed thousands of people and constructed rails and ships for over a century, before this successful industry closed in the 1970s. The site, south-east of Glasgow, was then reclaimed from dereliction during the 1990s to produce biomass through Short Rotation Coppice (SRC) of willow trees (*Salix* spp.). On site, the contaminated soil was removed, and a rudimentary substrate created with a mixture of sewage sludge and colliery spoil, the latter moved from nearby tips to release land for housing. Trees were planted and earthworms (Annelida) added to potentially assist growth. Initially recognised as a flagship for reclamation, the site was then abandoned. In 2018, information was gathered on the development of soils and on earthworm communities. This was achieved by sampling across the 35 ha site below willow, other planted tree species and grassland. The results showed that reclaimed soils were very stony, compacted, resistant to water infiltration but relatively uncontaminated. Willow had grown, but coppicing had not occurred. Earthworm introduction was initially unsuccessful, but colonisation took place from adjacent unadulterated areas and 16 species from three ecological groups were recorded. Mean community density was 208 ± 18.1 earthworms m^{-2} with a mean mass of 71 ± 6.1 g m^{-2}. Type of vegetation cover had a significant ($P < 0.05$) effect on community density and biomass. The site is now used for recreation and is an effective greenspace close to Glasgow.

INTRODUCTION

The site of the Hallside steelworks is 16 km south-east of Glasgow, close to the town of Cambuslang in South Lanarkshire, Scotland. Steel production took place there from 1873 until its closure in 1978. This steel supported war efforts and was used in the construction of railways, ships and the Forth Railway Bridge, with over 2,000 people employed on site during the Second World War (Borthwick, 1973). Fig. 1 shows an Ordnance Survey map of the site at its prime in 1934 (National Grid Reference: NS667602) and further images of the working site can be viewed online (Hampson, 2019). After over a century of steel production, buildings and structures were demolished during the early 1980s to leave the area derelict, covered with extensive concrete foundations, open basements and spoil heaps (locally referred to as bings) and contaminated with heavy metals (Borthwick, 1973; Richards *et al*., 1993; Scottish Greenbelt Company, 1996). For this reason, the site was regarded as a severe environmental problem due to the costs associated with "cleaning it up" through conventional reclamation methods, which would have involved the importation of good quality subsoil and topsoil.

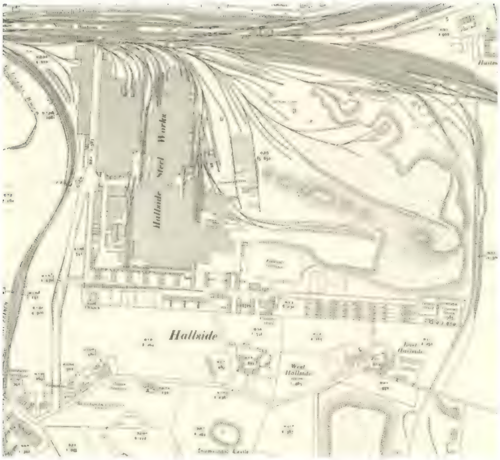

Fig. 1. OS map of Hallside steelworks, Lanarkshire, Scotland from 1934 (available online from Borthwick, 1973).

Development for housing or industry was therefore deemed unviable, so the site lay abandoned for over a decade. It was then acquired by the Strathclyde Greenbelt Company (later to become the Scottish Greenbelt Company), a charitable organisation whose main objective was to "sustain and enhance the landscape and ecological value of the Strathclyde Greenbelt" (Richards *et al*., 1993). With a need for new housing in the Clydesdale area during the early 1990s, development of greenbelt land was approved to the south of Hallside, with the agreement that this would be accompanied by the reclamation of the steelworks site to greenbelt use (by way of greenbelt mitigation). The proposed development sites were occupied by colliery spoil heaps which were cleared to make way for housing, which in turn financed the reclamation process (Richards *et al*., 1993; Scottish Greenbelt Company, 1996).

It was proposed that a large portion of the Hallside site would be used to create a "Renewable Energy Park", used for Short Rotation Coppice (SRC) of fast-growing tree species such as willow, which would provide wood for energy production. SRC harvest was proposed to occur every four to six years, following a staggered planting regime to ensure trees were available on an annual basis. A processing plant for the harvested wood was included in the development plans. The remainder of the site was to be planted as a broad-leaved community woodland to provide a screen between the energy forest and residential areas, to include pedestrian and cycle routes for recreational use (Richards *et al*., 1993). Organisations including the West of Scotland Water Authority, Scottish Enterprise, the Forestry Commission and Scottish Natural Heritage were initially involved in this project, as attested by a plaque (Fig. 2) that was ceremoniously unveiled on site by the Minister for Agriculture, Energy and the Environment in June 1996.

Fig. 2. Plaque to the "Hallside Renewable Energy Park" unveiled 1996, photographed 2005. (Photo: K.R. Butt)

After the removal of remaining concrete, metalwork and contaminated soil, a stone-rich material (colliery spoil) transported from nearby bings, as extracted and tipped decades before, was used to create a 1-2 m deep rudimentary "soil" at Hallside. To improve the soil for tree growth, 300 tonnes ha^{-1} of sewage sludge (bio-solids) was ploughed into the surface layers of the spoil to act as a fertiliser (Craven, 1995). Sewage was supplied from the local Daldowie sewage treatment works, which, until the European Union's Waste Water Directive came into effect in the 1990s, had previously disposed of sewage directly into the sea (Sutcliffe, 1997). It was hoped that the use of a high level organic fertiliser would accelerate the regeneration process and assist tree growth. To test this, pot trials had been established in 1992 using willow, poplar (*Populus* spp.) and red alder (*Alnus rubra*), to compare growth rates on colliery soil from Hallside with and without organic amendments (Craven, 1995). From these results, numerous species of willow were selected. Approximately 250,000 willow saplings were planted on the site in 1996, with a further 25,000 hardwood saplings planted to create an amenity hedgerow (Craven, 1995; Rees, 2010).

At the time of tree planting (1996) and to potentially assist tree growth and soil development, earthworms were added (inoculated) to the site through use of the Earthworm Inoculation Unit (EIU) technique (Butt *et al*., 1995) with N = 2,000 EIUs, each containing four adult *Lumbricus terrestris,* a deep burrowing (anecic) earthworm, and by depositing commercially supplied, earthworm-rich turf discs (150 mm diameter; 30 mm depth). The latter contained a mixture of earthworms, dominated (96%) by surface living (epigeic) species such as *Dendrobaena veneta* and *Eisenia fetida* (Butt, 2008). Previous trials (Craven, 1995) had suggested that anecic earthworms might successfully survive within the colliery spoil and sewage sludge mix and thereby effectively colonise the site. However, monitoring of the site over the two years after earthworm addition indicated that both inoculation techniques had been poorly implemented and few earthworms had persisted (Bain *et al.,* 1999; Butt, 2008). The site was further monitored in 2000 (Mitchell, 2001) and it was found that by then earthworms had colonised the substrate and spread widely. An initial community (N = 9 species) was dominated by the semi-aquatic, epigeic species *Eiseniella tetraedra*, with epigeics accounting for 95% of earthworms overall. Very few (2%) endogeic (shallow burrowing) species were present and *L. terrestris* made up less than 1% of the community. The overall community density was 188 earthworms m^{-2}. Further (small scale) monitoring took place in 2005 (Butt & Lowe, 2005), nine years after the initial inoculation, when 12 earthworm species were found on site. These continued to be dominated by epigeics (53%) of which *Lumbricus rubellus* and *E. tetraedra* were well represented. *Aporrectodea caliginosa* (the grey worm) was most frequent of the endogeic species which accounted for 38% of all earthworms.

After reclamation, few records of soil parameters were reported. One exception is from Mitchell (2001), whose earthworm-related M.Sc. project reported soil pH values of 5.5-7.5 from sampling points across the site. The site, which ought to have been coppiced on a regular basis over the period from the turn of the millennium, was largely neglected. The proposed processing plant was never built, although the willow grew well. The privately-owned Hallside Energy Park, never known to have produced commercial biomass, was fully abandoned in 2009, at which time responsibility was taken over by the Drumsagard Village Residents Association (DVRA) (Paterson, 2018). No further mention of the proposed Energy Plant for processing the willow has been found in the literature. The DVRA now manage the site for recreational use by the local community.

New investigations of the Hallside site took place in 2018, with a specific focus on soils and earthworms. The specific aims were (1) to assess the extent of soil development in the 22 years since reclamation and (2) to examine the communities of earthworms that were present and relate these to inoculations and/or colonisation from adjacent areas.

METHODS

Sampling points

During spring 2018, investigations were undertaken within the reclaimed areas from the 1990s, with comparisons drawn from sampling in adjacent areas that were unadulterated. Fig. 3 shows an aerial view of the site and the 24 selected sampling points. Most of these were in the dominant vegetation (willow) but other tree-covered areas were also targeted along with more open grassland.

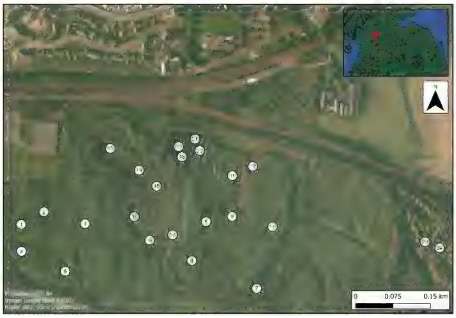

Fig. 3. Aerial view of the 35 ha reclaimed Hallside site, with position of the 2018 sampling sites indicated: 1-12, willow (*Salix* spp.); 13-17, grassland; 18-19, birch (*Betula* sp.); 20, Norway spruce (*Picea abies*); 21, Scots Pine (*Pinus sylvestris*); 22, cherry (*Prunus* sp.); 23-24, aspen (*Populus tremula*). Inset shows position of site in lowland Scotland (EDINA Digimap Service / Google Earth 2020).

Soils

Pits were dug, as deeply as possibly, in randomly chosen areas across the reclaimed site. This was to expose the soil profile and determine horizon development. At selected sites, under different vegetation cover, soil samples at 0-10 cm, were collected from each point and placed in sealed polyethylene bags to prevent moisture loss. In the laboratory, these were analysed for percentage moisture content, pH, percentage organic matter content - by loss on ignition (LOI) and by hand texturing (MAFF, 1981). Concentrations of heavy metals within soil samples were analysed using an Inductively Coupled Plasma Mass Spectrometer (ICP-MS) (Thermo Scientific X Series 1). Each soil sample was oven-dried at 80°C for 24 h. Total C and N was determined using a C, N Elemental Analyser (Carlo Erba (THERMO), FLASH EA 1112 Series).

Penetration resistance was measured at the selected sampling point using a 06.01 Eijkelkamp penetrometer, which gave a single reading for each insertion. Water infiltration rate was also measured within selected habitats, using a plastic cylinder (void area 95 cm^{2}) hammered into the soil and one litre of water added (adapted from Lassabatère *et al*., 2006). Infiltration rate was recorded or, if water remained after 5 min, the remaining depth (cm) was measured, with calculations to give infiltration rate (l min^{-1}). Three replicates of all measurements were taken per sample site.

Earthworms

The earthworms on site were sampled by digging a 0.1 m^{2} soil pit to 25 cm and hand-sorting the soil extracted on plastic sheeting in the field (N = 3 per location). In addition, to extract deep burrowing earthworms, an expellant of mustard powder and water (5 g l^{-1}) was applied to the base of the soil pit (Butt & Grigoropoulou, 2010) (see Fig. 4). Earthworms were preserved in 4% formaldehyde for identification using the nomenclature of Sherlock (2018). In the laboratory, preserved masses were determined individually for species from each site and assigned to Bouché's (1972) ecological categories (epige, endoge or anecic). Statistical methods (ANOVA) were applied, as appropriate, to determine if the vegetation cover had an effect on the earthworm community density or biomass (per unit area). Willow sampling points were subdivided into either standard and "wet", based on observed standing water and tree height. In addition, Shannon-Wiener diversity index calculations were made, and comparisons drawn with previous (2000 and 2005) monitoring results from the site.

Fig. 4. Sampling for soil and for earthworms among willow at Hallside in 2018. (Photo: K.R. Butt)

RESULTS

Soils

Soils in the reclaimed areas proved very difficult to dig as they had a high stone content. No pits could be dug further than a depth of 0.45 m and many digging attempts were hampered by large rocks. Fig. 5 shows that above the dark compacted, stone-laden horizon, there was a lighter less stony, organic A-horizon of some 0.15 cm from the soil surface. In control soils away from the reclamation site, major differences were observed (Fig. 5). Here, digging to 1 m was possible, with the upper (0-35 cm) organic layer determined as a grey, sandy clay loam above 35-100 cm of yellow sand. The upper layer held small fragments of colliery spoil as the area had previously been agricultural land and had been ploughed prior to alder planting.

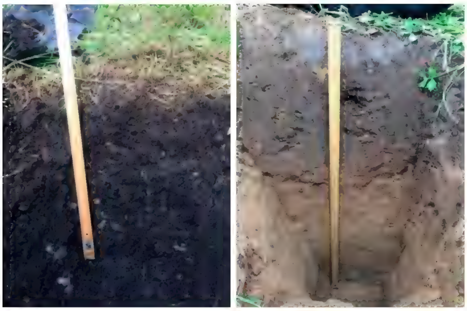

Fig. 5. Soil pits at Hallside. Left: in reclaimed soils below grassland (only possible to 45 cm due to stones and compaction). Right: in unadulterated sandy soil below aspen (to 1 m). (Photo: K.R. Butt)

Table 1 shows results of selected physical and chemical properties (including heavy metals) from soil samples across site. The pH results are relatively consistent within a range of 1.5 units on the acidic side of neutral (5.1-6.6). These include slightly more acidic conifer-influenced soils, although the sandy soil of the control area (below aspen (*Populus tremula*)) also had a pH close to 5. Values for LOI of 18-27% obtained from the reclaimed areas were high compared with control soil value of 6%. From nitrogen values within the reclaimed soils, C:N ratios of 3:1 to 10:1 were calculated. Sewage sludge will have initially promoted high nitrogen levels and accounted for growth of vegetation across site. Willow trees, originally intended to be coppiced after 4-6 years, reached heights of 12 m in some locations. However, where site drainage was poor, trees had survived, but with reduced growth. Soil moisture values ranged from 28-35% in reclaimed soils, compared with 25% in control areas. Infiltration of water varied across the site but was poor in places and mainly influenced by vegetation type. Some areas of the site had standing water at certain times of year but, were covered in terrestrial vegetation, further suggesting poorly-drained soils.

Earthworms

The investigations across site produced some 1,500 earthworms from 16 species (Table 2) equivalent to a mean (± s.e. (standard error)) community density of 208 ± 18.1 earthworms m^{-2} and a mean mass of 71 ± 6.1 g m^{-2}. Seven of these species were present in high numbers at the adjacent control site within natural soils. An additional two species were of those inoculated to the site using the turf discs in 1996. Two species (*Murchieona muldali* and *Octolasion lacteum*) were previously unrecorded from Hallside. Comparisons of different vegetation types showed a significant effect ($P < 0.05$) of habitat (differing dominant tree cover or grassland) on both earthworm community density and on biomass (Table 3). Fig. 6 shows the numbers of the different ecological categories of earthworms in these habitats. On the reclaimed site, significantly more earthworms were located where birch (*Betula* sp.) (height 12-15 m) was planted and where grassland had developed (community densities of 274 and 294 earthworms m^{-2} and biomasses of 104 and 75 g m^{-2} respectively: Table 3). These habitats compared favourably with natural (i.e. unpolluted and ploughed) control soils, planted with aspen, with 267 earthworms m^{-2}, and a biomass of 114 g m^{-2}. Overall, areas where willow was present (including good and poor growth) and those supporting two coniferous tree species (Norway spruce (*Picea abies*) and Scots pine (*Pinus sylvestris*)) had intermediate community densities of 153, 187 and 193 earthworms m^{-2}, respectively. However, when sub-divided by soil conditions, the standard willow then showed earthworm densities similar to those of grassland, birch and aspen, with significantly less within "wet willow". Below conifers, a mat of needles covered the soil surface and was particularly dense below Norway spruce. Soil below cherry (*Prunus* sp.) supported the smallest recorded number of earthworms, with a mean of 83 earthworms m^{-2}.

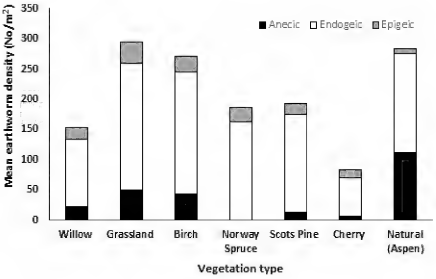

Fig. 6. Earthworm community data (by ecological category) at Hallside from below a variety of vegetation types on reclaimed soils and a more natural adjacent soil.

Overall, of the earthworms collected in 2018, endogeics accounted for 74% with *A. caliginosa*, *Aporrectodea rosea*, *Octolasion cyaneum* and *Allolobophora chlorotica* (green and pink morphs combined) equating to 34%, 27%, 8% and 5% respectively. The major anecic species was *Aporrectodea longa* (13%). Epigeics accounted for only 5% of all earthworms and were dominated by *Dendrobaena octaedra* (4%).

Soil Property Vegetation	C:N	pH	Moisture (%)	Loss on Ignition (%)	Infiltration (litres min^{-1})	Penetration Resistance (N cm^{-2})	Cr (ppm)	Ni (ppm)	Cu (ppm)	Zn (ppm)	Cd (ppm)	Pb (ppm)
Willow	9.55	6.13	31.7 ± 2.0	24.6 ± 1.8	0.90 ± 0.26	72.4 ± 3.6	102.38	83.25	166.27	1723.78	6.62	419.25
Grassland	4.83	6.63	32.4 ± 3.6	27.3 ± 6.9	0.52 ± 0.23	72.1 ± 4.7	72.06	70.13	125.95	560.01	1.74	316.176
Birch	8.71	6.12	32.3 ± 2.0	24.8 ± 2.7	0.32 ± 0.12	64.1 ± 4.6	67.61	58.69	45.54	473.97	0.61	109.22
Norway spruce	2.99	5.13	28.5 ± 0.9	18.0 ± 1.0	1.20 ± 0.13	72.1 ± 6.9	62.52	57.29	47.34	122.57	0.64	80.83
Cherry	3.90	5.83	34.7 ± 0.6	20.4 ± 0.8	Not recorded	Not recorded	68.84	77.97	73.79	247.24	0.93	152.5
Scots Pine	5.80	5.43	33.2 ± 3.0	25.9 ± 2.6	0.32 ± 0.03	93.1 ± 16.5	65.60	63.25	70.58	439.77	1.57	172.38
Natural (Aspen)	1.91	5.06	24.8 ± 2.9	6.1 ± 1.0	0.10 ± 0.01	62.1 ± 2.0	83.50	90.37	206.40	675.15	3.02	513.92

Table 1. Selected mean (± s.e.) physical and chemical soil properties at Hallside, Lanarkshire, Scotland (2018) (adapted from Butt & Quigg, 2020).

Earthworm species	DAFOR (2018)	Ecological category	Inoculated (1996)	Present in 2000	Present in 2005	In Natural area (2018)
Allolobophora chlorotica (green morph)	Occasional	En	X	X	X	
Allolobophora chlorotica (pink morph)	Rare	En			X	
Aporrectodea caliginosa	Dominant	En		X	X	X
Aporrectodea longa	Frequent	A		X	X	X
Aporrectodea nocturna	Rare	A			X	
Aporrectodea rosea	Abundant	En	X		X	X
Dendrobaena octaedra	Occasional	Ep		X		
Dendrodrilus rubidus	Rare	Ep	X	X		
Eiseniella tetraedra	Rare	Ep		X	X	
Lumbricus castaneus	Occasional	Ep		X	X	X
Lumbricus rubellus	Occasional	Ep		X	X	X
Lumbricus terrestris	Occasional	A	X	X	X	X
Murchieona muldali	Rare	Ep				
Octolasion cyaneum	Frequent	En			X	X
Octolasion lacteum	Rare	En				
Satchellius mammalis	Rare	Ep			X	

Table 2. List of all earthworm species present within the reclaimed Hallside area, Lanarkshire, Scotland in 2018 (with subjective frequency (DAFOR) and ecological category: A, anecic; En, endogeic; Ep, epigeic) with reference to those inoculated, previously found on site, and present (2018) in an adjacent undisturbed area (adapted from Butt & Quigg, 2020).

	Vegetation Cover							
Earthworm data	**Willow**	**Wet willow**	**Grassland**	**Birch**	**Spruce**	**Pine**	**Cherry**	**Aspen (Natural)**
Mean earthworm density	244.4 ± 23.0	48.0 ± 10.3	294.0 ± 48.8	274.4 ± 52.4	186.7 ± 43.7	193.3 ± 46.3	83.3 ± 6.7	266.7 ± 40.4
(No. m^{-2} ± s.e.)	a	b	a	a	ab	ab	b	a
Dominant spp. by number (%)	A.cal (42)	A.cal (30)	A.ros (32)	A.ros (36)	O.cyan (61)	A.cal (58)	A.cal (38)	A.long (35)
	A.ros (19)	D.oct (13)	A.cal(28)	A.cal (32)	A.cal (21)	A.ros (25)	A.ros (21)	A.cal (31)
	O.cyan (10)	D.rub (12)	A.long (14)	A.long (15)	L.rub (9)	A.long (7)	A.chlor (17)	A.ros (26)
Mean earthworm biomass	86.1 ± 10.8	23.98 ± 6.05	75.3 ± 11.9	103.8 ± 20.3	62.0 ± 14.3	58.0 ± 13.7	22.2 ± 10.4	114.4 ± 27.1
(Mass g m^{-2} ± s.e.)	a	b	a	a	ab	ab	b	a
Dominant spp. by mass (%)	A.cal (29)	A.cal (23)	A.long (40)	A.long (42)	O.cyan (71)	A.cal (57)	A.long (50)	A.long (62)
	L.ter (19)	A.noct (18)	A.cal (23)	A.cal (22)	A.cal (16)	A.long (55)	A.cal (25)	A.cal (16)
	O.cyan (19)	O.cyan (13)	L.ter (14)	A.ros (12)	L.rub (9)	A.ros (10)	A.ros (12)	A.ros (9)

Table 3. Earthworm community density and biomass across vegetation types sampled at Hallside, Lanarkshire, Scotland in 2018. Different letters in the same row indicate a significant difference ($P < 0.05$). A.cal, *Aporrectodea caliginosa*; A.chlo, *Allolobophora chlorotica*; A.long, *Aporrectodea longa*; A.noct, *Aporrectodea nocturna*; A.ros, *Aporrectodea rosea*; D.oct, *Dendrobaena octaedra*; D.rub, *Dendrodrilus rubidus*; E.tet, *Eiseniella tetraedra*; L.rub, *Lumbricus rubellus*; L.ter, *Lumbricus terrestris*; O.cyan, *Octolasion cyaneum.*

The greatest proportion (39%) of deep burrowing earthworms was located in the control soils adjacent to the reclaimed site. Comparisons below each type of vegetation can be seen in Table 3.

Earthworm diversity across the site was characterised by a Shannon (H) Index of 1.89 with an evenness (measure of similarity between numbers of different species) of 0.68. Comparisons of previous monitoring at Hallside, for diversity, evenness and species richness, are also provided in Table 4.

DISCUSSION

Soils

In the reclaimed areas where soils were created, it appears that physical challenges, such as soil compaction, now outweigh any chemical problems for soil fauna that existed in the contaminated soils of the old steelworks. The current chemical nature of the reclaimed soils is such that soil fauna (specifically earthworms) can survive. Recorded levels of chromium and of cadmium fall within U.K. soil guideline values for residential use and allotments (DEFRA, 2018) (Table 1). Mean lead levels vary across site, but soil guide values are not available for this element. Most soil contaminants were removed from site before reclamation, but some metal contaminants must have been introduced with the spoil and sludge (Craven, 1995). The willow grown on site, in addition to providing a useful product, could also have assisted with decontamination of the site through uptake into the plants themselves (phytoremediation), although this was not given as one of the primary objectives at the time of reclamation. As willow biomass was not removed from site, this did not occur. High values for LOI could in part be attributed to the presence of combustible coal particles in the spoil, remnants of the sewage sludge and with more recent additions from the leaf litter of the given trees present. The acidic pH values were consistent with those reported by Mitchell (2001) from sampling nearly two decades earlier. Remnants of pyrites within the colliery spoil (Craven, 1995) may well keep these below neutral.

To overcome some of the physical challenges that still exist on site, greater thought could have been given to site preparation before tree planting. Although tree performance in most areas is acceptable on this type of land, sub-soiling may have alleviated the compaction problems, as recorded at restored colliery sites (Scullion & Mohammed, 1991) and would certainly have prevented some of the problems associated with water pooling at the soil surface.

Earthworms

Historical data and current monitoring (Table 2) indicate that earthworm colonisation of the reclaimed site has occurred, with community density and biomass (208 m^{-2} and 71 g m^{-2} respectively) now equivalent to records from numerous U.K. pasture and woodland sites (Edwards & Bohlen, 1996). The Hallside records are also equivalent to values (203 m^{-2} and 56 g m^{-2}) obtained by Scullion & Mohammed (1991) from rehabilitated (sub-soiled and fertilised) grassland on an opencast mining site, where soils may be considered similar.

Differences in earthworm community density and biomass that have developed below different stands of trees and on grassland can be attributed to the quality of the leaf litter produced. Willow, whilst supporting fewer earthworms, was planted to dominate this site for coppice production and the low lying (wet) soils seem to have favoured this tree species. However, where planted to gather data on growth rate and survival, other tree species (particularly birch) have survived. Future work could usefully investigate these directly for growth parameters and a range of associated soil macro-, meso- and micro-fauna.

As earthworm community density has increased, so has species richness at Hallside. This, however, is only something that can be learned from long term monitoring of a site. Investigations are usually short-term, i.e. three to five years, but lengthier monitoring can prove to be invaluable, as not only do numbers change, but the proportions of the given species (community composition) can also be dynamic. Results for the major species recorded at Hallside have shown a steady increase in endogeics and a decrease in the epigeics, typified by *E. tetraedra,* which Mitchell (2001) reported as dominant, but which had decreased to become a minor component of the earthworm community by 2018. As this species is semi-aquatic, its decrease may be attributed to changes in soil moisture dynamics on site and a decrease in the bio-solids content.

Monitoring Year	Years after restoration	Species richness (S)	Shannon-Wiener Index (H)	Evenness (E)	Major Species across site (%)
2000	4	9	1.01	0.46	E.tet (67); L.rub (18); D.oct (9).
2005	9	12	2.16	0.87	A.cal (19); L.rub (19); E.tet (18).
2018	22	16	1.89	0.68	A.cal (34); A.ros (27); A.long (13).

Table 4: Species richness and diversity parameters of earthworms from Hallside, Lanarkshire, Scotland at post-restoration monitoring. Earthworm species abbreviations as for Table 3.

Monitoring has shown that the soils at Hallside are compacted, have a high stone content and are resistant to water infiltration. The presence of deep burrowing earthworm species, such as *L. terrestris*, which create large burrows (diameter 7 mm; depth >1 m) as a part of their everyday existence (e.g. Butt & Grigoropoulou, 2010), would probably help and was one reason why this species was inoculated to site by managers in 1996. However, soils were too embryonic at that stage and incapable of offering support. Some 20 years on, an inoculation of this nature might still be inappropriate. Despite colonisation by some species, *L. terrestris* still struggles to produce deep burrows in these compacted, stone-rich soils and is forced to exist in shallow burrows, as previously recorded by Butt *et al.* (2014). *A. longa*, a smaller anecic species, is more suited to the soil conditions that have developed at Hallside as shown by its dominance of this ecological category. It may well have been a better candidate species for inoculation when the site was initially reclaimed.

Conclusion

From this investigation at Hallside, the given aims relating to reclaimed soils and earthworm community development have been addressed. These data may represent one of the final chapters in the narrative of this site. After more than two decades, reclamation at the Hallside steelworks site can be viewed mainly as a success. It has replaced a contaminated site and a large colliery waste heap, with a green space in an urban landscape. The site is now predominantly used by dog walkers and families for recreational purposes and a proposed development of the site has been made to create additional pathways within the woodland, to allow further access by members of the public. In addition, proposals to create new habitats and enhance existing habitats have been suggested, in order to increase biodiversity on site (Paterson, 2018). Rather than the plaque (Fig. 2) of the Renewable Energy Park that never was, a more fitting commemoration (Fig. 7) to the Hallside Steelworks is now present in the Park and Ride area of Newton Railway Station.

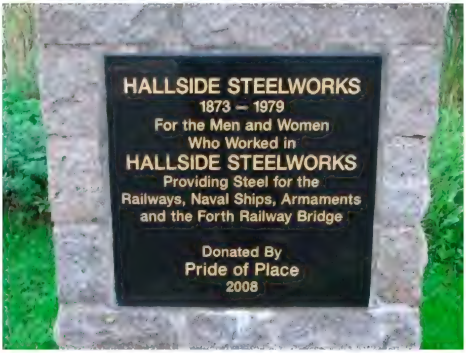

Fig. 7. Commemorative plaque to the Hallside Steelworks photographed in 2017. (Photo: K.R. Butt)

ACKNOWLEDGEMENTS

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Oribatid mites (Acari: Oribatida) of the Isle of Man revisited

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ABSTRACT

This paper is based on a collection of oribatid mites from the Isle of Man, British Isles that was made during a survey of the island conducted in 1988. A total of 172 species and one subspecies of oribatid mites has now been recorded for the Isle of Man, in comparison with 363 species for the whole of Britain. Twelve of the species and one subspecies reported herein are new to Britain, namely: *Ceratozetes conjunctus*, *Ceratozetes* sp., *Liochthonius alpestris*, *Neoliochthonius globuliferus*, *Oppiella* (*Oppiella*) *splendens*, *Oribatula longilamellata*, *Pantelozetes berlesei*, *Planoristes acuspidatus*, *Scheloribates minifimbriatus*, *Serratoppia serrata*, *Suctobelbella* sp., *Tectocepheus velatus alatus* and *Zygoribatula propinqua.* A checklist of all oribatid mites found to date in the Isle of Man is provided.

INTRODUCTION

The acarine suborder Oribatida (also called Cryptostigmata) is one of the most numerically dominant arthropod groups in the organic horizons of most soils. Globally, over 10,000 species have been described (Subías, 2019), which is considered to represent one third to one tenth of the true diversity (Walter & Proctor, 2013; Behan-Pelletier & Lindo, 2019). Monson (2011) provides a brief introduction to British oribatid mites.

Previously published records for the Isle of Man can be found in Luxton (1987). The present study was based on material collected by M.L. in 1988. The collection forms part of the Luxton Archive given to the National Museums Liverpool on M.L.'s retirement.

This paper is intended to update and expand Luxton's 1987 account, and provides a checklist of all oribatid mite species found to date in the Isle of Man.

MATERIALS & METHODS

A total of 135 samples was collected from 36 locations. The samples were confined to small polythene bags for transport to the extractor in Liverpool. The necks of the bags were tied to conserve moisture and small paper tags were looped around the consequent knots by their attaching string. The paper tags were labelled fully, in pencil, in the field. Thus, on transferring the sample to the extractor, they could be pulled free of the string and used in the collecting vessel obviating the need to write a second label. Banks of Tullgren funnels were used for extraction over a period of one day for each extraction and the catch was collected in a 70% glycerol mixture in plastic pots. On completion of extraction, the volume of liquid in the pot was tripled by the addition of absolute alcohol and a snap on lid secured tightly to prevent evaporation. Specimens were examined in a stereomicroscope and compound light microscope when temporarily mounted in 100% lactic acid on glass cavity slides at room temperature. For species new to Britain, specimen counts were made. Identified specimens were stored in 70% alcohol and deposited in National Museums Liverpool (Entomology Department).

SITES STUDIED (see Fig.1)

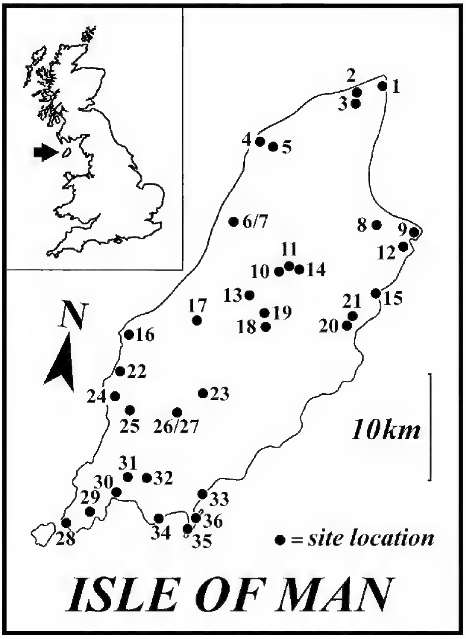

Fig. 1. Location of the Isle of Man (arrowed in the inset map of Britain) and sites where samples were collected.

Site 1. Point of Ayre, 21.4.88 (NX468047): Sample 652, gorse (*Ulex*) litter. Sample 654, marram grass (*Ammophila*) litter. Sample 658, lichen (*Xanthoria parietina*) from concrete of old gun emplacement.

Sample 662, moss and heather (*Calluna*) litter. Sample 665, moss on sand.

Site 2. The Ayres, near Visitor Centre, 17.4.88 (NX439039): Sample 618, dry heather (*Calluna*) litter. Sample 625, gorse (*Ulex*) litter. Sample 695, lichen (unidentified) on sand. Sample 709, moss on sand.

Site 3. Manx National Trust (New Site), The Ayres, 21.4.88: Sample 656 (NX433035), bracken (*Pteridium*) litter. Sample 660 (NX432032), grass turf in wet slack. Sample 663 (NX435035), moss beneath pine (*Pinus*). Sample 671 (NX432032), moss (*Sphagnum*) from a wet slack. Sample 676 (NX432032), mossy turf in wet slack. Sample 682 (NX435035), pine (*Pinus*) litter.

Site 4. Sartfield, 21.4.88 (SC353997): Sample 667, moss on dunes.

Site 5. Ballaugh Curraghs near Ballaugh, 21.4.88 (SC365956): Sample 647, thin, dryish moss from willow (*Salix*) trunk. Sample 655, moss (*Sphagnum*) on ground. Sample 657, from lichen (*Parmelia saxatilis*) on willow trunk. Sample 666, dryish willow (*Salix*) litter. Sample 669, grass (*Molinia*) litter. Sample 670, waterlogged willow (*Salix*) litter.

Site 6. Orrisdale, near Kirk Michael, 22.4.88 (SC329928): Sample 653, moss on asbestos roof. Sample 678, beech (*Fagus*) litter. Sample 688, moss on ground beneath trees.

Site 7. Bishopscourt Glen, near Kirk Michael, 22.4.88: Sample 691 (SC331924), mixed deciduous litter. Sample 736 (SC331924), woody plant (*Rhododendron*) and palm litter. Sample 748 (SC333922), moss (*Sphagnum*) on soil bank.

Site 8. Ballure Plantation, 17.4.88 (SC454923): Sample 624, moss (*Polytrichum*) from above drainage ditch. Sample 633, spruce (*Picea*) litter. Sample 703, lichen (unidentified) and soil from above drainage ditch opposite Ballure Plantation. Sample 716, moss on tree stump.

Site 9. Maughold, 17.4.88 (SC493917): Sample 620, moss on stone wall.

Site 10. Ballaugh Plantation, near Ballaugh, 21.4.88 (SC367912): Sample 651, pine (*Pinus*) litter.

Site 11. Tholt-e-Will Glen, 21.4.88: Sample 645 (SC378891), blue pine (*Pinus wallichiana*) litter. Sample 646 (SC378890), moss on slate wall. Sample 648 (SC378891), moss (*Polytrichum*) on ground beneath pine (*P. wallichiana*). Sample 649 (SC377888), heather (*Calluna*) litter on moor opposite Tholt-e-Will Glen. Sample 661 (SC378891), moss on tree stump. Sample 664 (SC378891), very wet liverworts/moss on soil bank. Sample 677 (SC377888), moss among heather, opposite Tholt-e-Will Glen.

Site 12. Dreemskerry Quarry, 17.4.88 (SC477911): Sample 710, wet moss on cliff.

Site 13. Sartfell Plantation, 19.4.88: Sample 619 (SC344866), moss beneath heather (*Calluna)* on bank at edge of pine (*Pinus*) stand. Sample 636 (SC344866), moss (*Sphagnum*) from drainage ditch at edge of Plantation. Sample 705 (SC344866), tree (*Thuja*/*Cupressus*) litter. Sample 707 (SC344865), from wet heather (*Calluna*) litter and moss from ground local to Plantation. Sample 746 (SC344866), pine (*Pinus*) litter.

Site 14. Snaefell near The Bungalow, 21.4.88 (SC387880): Sample 650, grass turf. Sample 668, very wet moss on rock face.

Site 15. Glen Dhoon, 19.4.88 (SC455865): Sample 629, liverworts on soil bank. Sample 630, thin, slimy moss/liverworts on tree stump. Sample 631, mixed deciduous leaf litter. Sample 699, moss on ash trunk. Sample 751, moss on soil bank.

Site 16. The Raggett, near Peel, 18.4.88 (SC244830): Sample 617, larch (*Larix*) litter. Sample 621 gorse (*Ulex*) litter. Sample 622, mixed tree litter. Sample 639, moss on sycamore trunk. Sample 693, moss on soil beneath sycamore. Sample 698, oak (*Quercus*) litter. Sample 702, moss on rocks. Sample 732, grass and bracken (*Pteridium*) litter.

Site 17. Glen Helen, 23.4.88 (SC298843): Sample 640, larch (*Larix*) litter. Sample 700, moss on disintegrating tree stump. Sample 725, beech (*Fagus*) litter. Sample 735, moss on fallen log. Sample 742, moss on slate. Sample 744, liverworts on bank of soil on slate. Sample 749, moss on beech (*Fagus*) trunk. Sample 750, thick moss (*Sphagnum*) on soil bank.

Site 18. Colden Plantation, 19.4.88 (SC358837): Sample 641, moss on stone, edge of Norway spruce (*Picea abies*) stand. Sample 712, moss on tree stump. Sample 713, tree (*Abies*) litter.

Site 19. Injebreck, 19.4.88 (SC356848): Sample 634, moss (*Homalothecium sericeum*) on face of wall. Sample 635, wet moss on trunk of beech (*Fagus*). Sample 734, moss (*Polytrichum*) on top of wall. Sample 745, mixed deciduous beech/sweet chestnut (*Fagus*/*Castanea*) litter.

Site 20. Axnfell Plantation, near Laxey, 19.4.88 (SC423838): Sample 637, lichen on larch (*Larix*) trunk. Sample 706, moss on ground beneath larch (*Larix*). Sample 721, moss mound on old stone building. Sample 722, gorse (*Ulex*) litter. Sample 737, pine (*Pinus*) litter.

Site 21. Laxey Glen Gardens, Laxey, 19.4.88 (SC430843): Sample 627, beech (*Fagus*) litter. Sample 628, moss on bridge parapet. Sample 638, moss on ground beneath woody plant (*Rhododendron*). Sample 723, finely divided liverworts in running water on bank.

Sample 726, liverworts at edge of drainage ditch. Sample 729, moss on beech (*Fagus*) trunk.

Site 22. Glen Maye, 18.4.88 (SC233798): Sample 626, sycamore litter. Sample 704, moss on soil at edge of gorge. Sample 711, deep wet moss on wall of gorge near stream. Sample 715, liverworts on soil at edge of gorge. Sample 718, liverworts on rock.

Site 23. Archallagan Plantation, 23.4.88 (SC300780): Sample 724, moss on floor of pine (*Pinus*) stand. Sample 741, pine litter.

Site 24. Niarbyl, Elby Point, 20.4.88 (SC211777): Sample 643, lichen (*X. parietina*). Sample 686, thrift clump (*Armeria maritima*) on cliff. Sample 717, moss clumps on cliff face.

Site 25. Slieu Mooar Plantation, 18.4.88 (SC234764): Sample 616, moss on fallen spruce (*Picea*) trunk. Sample 632, spruce (*Picea*) litter. Sample 694, moss (*Galium saxatile*) and plant at edge of spruce (*Picea*) forest.

Site 26. South Barrule Plantation, 18.4.88 (SC277761): Sample 623, spruce (*Picea*) litter. Sample 692, moss (*Sphagnum*) in drainage ditch.

Site 27. Barrule Plantation, 18.4.88 (SC277761): Sample 719, wet moss beneath (*Calluna*) and young tree (*Abies*).

Site 28. Spanish Head, 20.4.88 (SC173667): Sample 642, lichen (*Ramalina siliquosa)*, on cliff top. Sample 674, gorse (*Ulex*) litter on cliff top. Sample 730, moss and powdery lichen on soil of cliff top. Sample 733, moss (*Polytrichum*?) on cliff top. Sample 743, grass clump in rock cleft.

Site 29. The Howe, 20.4.88 (SC198678): Sample 747, moss on wall.

Site 30. Ballagawne, 18.4.88 (SC223695): Sample 714, moss on wall opposite churchyard.

Site 31. Colby, 18.4.88 (SC232706): Sample 697, moss on wall.

Site 32. Ballabeg, 20.4.88 (SC247704): Sample 690, moss on wall.

Site 33. Cass-ny-Hawin Head, 20.4.88 (SC297693): Sample 683, moss on rock on slopes of inlet. Sample 689, gorse (*Ulex*) litter on cliff top at inlet. Sample 701, oak (*Quercus*) litter on slope of inlet. Sample 720, moss on oak (*Quercus*) trunk on slopes of inlet. Sample 740, bracken (*Pteridium*) litter on slope of inlet.

Site 34. Castletown (near), 18.4.88 (SC263682): Sample 696, moss on wall.

Site 35. Langness, 20.4.88 Sample 659 (SC282654), lichen (*X. parietina*) on conglomerate rock. Sample 672 (SC285658), heather (*Calluna*) litter on slate outcrop. Sample 673 (SC285658), lichen (*R. siliquosa*) on conglomerate rock. Sample 679 (SC283662), saltmarsh turf. Sample 680 (SC285658), moss on slate outcrop. Sample 681 (SC285 658), green/grey thallate lichen (*P. saxatilis*?) on slate outcrop. Sample 684 (SC285658), marine lichen (*Lichina pygmaea*) on conglomerate rock. Sample 687 (SC285658), gorse (*Ulex*) litter on slate outcrop. Sample 708 (SC282654), plant (*Armeria*) clump on conglomerate rock. Sample 727 (SC285658), gorse (*Ulex*) litter on slate outcrop. Sample 728 (SC282654), moss in damp area of conglomerate rock at top of shore. Sample 731 (SC285658), moss on slate outcrop. Sample 739 (SC285658), lichen (*R. siliquosa*) on slate.

Site 36. St. Michael's Isle, 20.4.88 (SC296673): Sample 644, lichen (*X. parietina*), on coastal rocks. Sample 675, lichen (*R. siliquosa*) on rock. Sample 685, plant (*Sedum*/*Armeria*) clump on rock. Sample 738 (SC296674) tidal debris, top of shore.

RESULTS

Unless otherwise stated, superfamily and family organisation are in accordance with Schatz *et al.* (2011) and lower level taxonomy is mainly in accordance with Weigmann (2006). In the text below "Britain" is used in the watsonian sense to refer to the island of Great Britain and its offshore islands, including the Isle of Man (Watson, 1852).

* = species listed in Luxton (1987)
† = species collected in 1988, new to Britain (bold text)
^ = species collected in 1988, not new to Britain
Each specific name is followed by sampling site number(s) and, as appropriate, historical notes.

Overview of oribatid mites found in the Isle of Man

Total number of species recorded = 172
Number of subspecies = 1
Number of species with genus assignation only = 2
Number of genera = 85
Number of families = 41
Number of species listed in Luxton (1987) = 60 (not 59 as stated in Luxton, 1987)
Number of species new to the Isle of Man found in the 1988 collection = 112
Number of species new to Britain found in the 1988 collection = 12

Checklist of oribatid mites found in the Isle of Man

Suborder Oribatida van der Hammen, 1968

Infraorder Enathronota Grandjean, 1969

Superfamily Brachychthonioidea Thor, 1934

Family Brachychthoniidae Thor, 1934
Genus *Brachychthonius* Berlese, 1910
**Brachychthonius berlesei* Willmann, 1928
Genus *Liochthonius* van der Hammen, 1952
†***Liochthonius alpestris*** (Forsslund, 1958) (622, 638, 663, 696, 709) (62 specimens).

Distribution: Palaearctic (Subías, 2019); Europe (Weigmann, 2006).
*^*L. brevis* (Michael, 1888) (623, 633, 640, 656, 663, 665, 671, 682, 687, 689, 694, 705, 706, 707, 722, 741, 746, 751).
^*L. clavatus* (Forsslund, 1942) (747).
^*L. lapponicus* (Trägårdh, 1910) (671).
^*L. perfusorius* Moritz, 1976 (633, 694, 706, 707, 722, 741, 751).
^*L. sellnicki* (Thor, 1930) (622).
^*L. strenzkei* Forsslund, 1963 (622).
Genus *Neoliochthonius* Lee, 1982
†***Neoliochthonius globuliferus*** (Strenzke, 1951) (707) (one specimen).
Distribution: Central Europe and Mexico (Subías, 2019); Europe (Weigmann, 2006).
^*N. piluliferus* (Forsslund, 1942) (696).
Genus *Poecilochthonius* Balogh, 1943
^*Poecilochthonius spiciger* (Berlese, 1910) (669).
Genus *Sellnickochthonius* Krivolutsky, 1964
^*Sellnickochthonius cricoides* (Weis-Fogh, 1948) (654, 656, 671).
^*S. honestus* (Moritz, 1976) (648).
^*S. rostratus* (Jacot, 1936) (622).
Note: *S. rostratus* is sometimes synonymised with *S. hungaricus* subsp. *rostratus*, although Weigmann (2006) regards it as a separate species.
Genus *Synchthonius* van der Hammen, 1952
*^*Synchthonius crenulatus* (Jacot, 1938) (671).

Superfamily Hypochthonioidea Berlese, 1910

Family Eniochthoniidae Grandjean, 1947
Genus *Eniochthonius* Grandjean, 1933
^*Eniochthonius minutissimus* (Berlese, 1903) (640, 740, 748).

Family Hypochthoniidae Berlese, 1910
Genus *Hypochthonius* C.L. Koch, 1835
*^*Hypochthonius rufulus* C.L. Koch, 1835 (617, 622, 623, 638, 640, 648, 664, 694, 703, 706, 725, 732, 736, 740, 741).

Infraorder Mixonomata Grandjean, 1969

Superfamily Eulohmannioidea Grandjean, 1931

Family Eulohmanniidae Grandjean, 1931
Genus *Eulohmannia* Berlese, 1910
^*Eulohmannia ribagai* (Berlese, 1910) (638).

Superfamily Euphthiracaroidea Jacot, 1930

Family Euphthiracaridae Jacot, 1930
Genus *Acrotritia* Jacot, 1923
^*Acrotritia duplicata* (Grandjean, 1953) (640, 713).

Superfamily Phthiracaroidea Perty, 1841

Family Phthiracaridae Perty, 1841
Genus *Phthiracarus* Perty, 1841
**Phthiracarus affinis* (Hull, 1914)
^*P. ferrugineus* (C.L. Koch, 1841) (622, 655, 666, 670).
**P. longulus* (C.L. Koch, 1841)
^*P. montanus* C. Pérez-Íñigo, 1969 (622, 623, 626, 627, 631, 640, 651, 661, 672, 711, 729, 735, 737, 749).
Genus *Steganacarus* Ewing, 1917
^*Steganacarus* (*Steganacarus*) Ewing, 1917
^*Steganacarus.* (*Steganacarus*) *magnus* (Nicolet, 1855) (626, 627, 628, 631, 640, 648, 662, 674, 678, 682, 687, 689, 691, 701, 703, 706, 713, 725, 727, 736, 737, 740, 748).

Infraorder Desmonomata Woolley, 1973

Hyporder Nothrina van der Hammen, 1982

Superfamily Crotonioidea Thorell, 1876

Family Crotoniidae Thorell, 1876
Genus *Camisia* von Heyden, 1826
^*Camisia biurus* (C.L. Koch, 1839) (618, 619, 662, 707).
^*C. horrida* (Hermann, 1804) (620, 652, 690, 696, 733).
^*C. invenust*a (Michael, 1888) (646, 667, 681, 743).
^*C. segnis* (Hermann, 1804) (618, 619, 646, 652, 662, 698, 712, 731).
^*C. spinifer* (C.L. Koch, 1835) (672, 694, 706, 708, 722, 727, 731, 737, 741, 743).
Genus *Platynothrus* Berlese, 1913
*^*Platynothrus peltifer* (C.L. Koch, 1839) (619, 621, 622, 623, 624, 640, 648, 649, 650, 655, 666, 668, 669, 670, 677, 692, 700, 707, 710, 712, 713, 723, 725, 726, 737, 741, 748).
^*P. thori* (Berlese, 1904) (670).

Family Hermanniidae Sellnick, 1928
Genus *Hermannia* Nicolet, 1855
*^*Hermannia gibba* (C.L. Koch, 1839) (617, 622, 626, 627, 631, 640, 659, 688, 689, 700, 701, 711, 715, 717, 718, 732, 735, 736, 740, 748, 749).
^*H. pulchella* Willmann, 1952 (679).
*^*H. reticulata* Thörell, 1871 (618, 620, 624, 625, 646, 652, 654, 661, 668, 672, 685, 686, 703, 705, 709, 716, 731, 741, 745).

Family Malaconothridae Berlese, 1916
Genus *Malaconothrus* Berlese, 1904
**Malaconothrus monodactylus* (Michael, 1888)
Genus *Tyrphonothrus* Knülle, 1957
**Tyrphonothrus maior* (Berlese, 1910) (as *Trimalaconothrus novus* in Luxton, 1987).

Family Nanhermanniidae Sellnick, 1928
Genus *Nanhermannia* Berlese, 1913
*^*Nanhermannia coronata* Berlese, 1913 (624, 631, 649, 651, 661, 707, 719, 737, 741, 746).
^*N. elegantula* Berlese, 1913 (629, 713, 722, 723, 740).
**N. sellnicki* Forsslund, 1958

Family Nothridae Berlese, 1896
Genus *Nothrus* C.L. Koch, 1835
^*Nothrus anauniensis* Canestrini & Fanzago, 1876 (719).
*^*N. palustris* C.L. Koch, 1839 (617, 622, 659, 691, 715, 748).
^*N. silvestris* Nicolet, 1855 (623, 624, 633, 640, 648, 649, 651, 656, 662, 671, 685, 703, 707, 722, 740, 748).

Family Trhypochthoniidae Willmann, 1931
Genus *Trhypochthonius* Berlese, 1904
^*Trhypochthonius tectorum* (Berlese, 1896) (733, 739).

Hyporder Brachypylina Hull, 1918

Superfamily Neoliodoidea Sellnick, 1928

Family Neoliodidae Sellnick, 1928
Genus *Poroliodes* Grandjean 1934
^*Poroliodes farinosus* (C.L. Koch, 1840) (683).

Superfamily Damaeoidea Berlese, 1896

Family Damaeidae Berlese, 1896
Genus *Belba* von Heyden, 1826
^*Belba corynopus* (Hermann, 1804) (627).
Genus *Damaeus* C.L. Koch, 1835
^*Damaeus* (*Adamaeus*) *onustus* (C.L. Koch, 1844) (627, 701, 732).
^*D.* (*Damaeus*) *riparius* Nicolet, 1855 (617).
^*D.* (*Paradamaeus*) *clavipes* (Hermann, 1804) (636, 647, 674, 716).
Genus *Kunstidamaeus* Miko, 2006
^*Kunstidamaeus tenuipes* (Michael, 1885) (734).
Genus *Metabelba* Grandjean, 1936
^*Metabelba papillipes* (Nicolet. 1855) (617, 622, 689).
Genus *Porobelba* Grandjean, 1936
^*Porobelba spinosa* (Sellnick, 1920) (618, 624, 634, 640, 654, 656, 662, 671, 703, 706, 711, 714, 732, 734, 748).

Superfamily Cepheoidea Berlese, 1896

Family Cepheidae Berlese, 1896
Note: The name Cepheidae is a junior homonym of Cepheidae Agassiz, 1862 (Schatz *et al.*, 2011). Halliday & Norton (2019) have made a proposal to the International Commission of Zoological Nomenclature to emend the name; we retain the traditional spelling pending approval.
Cepheus C.L. Koch, 1835
^*C. latus* C.L. Koch, 1835 (623, 637).

Superfamily Zetorchestoidea Michael, 1898

Family Eremaeidae Oudemans, 1900
Genus *Eueremaeus* Mihelčič, 1963
*^*Eueremaeus oblongus* (C.L. Koch, 1835) (618, 620, 630, 634, 652, 654, 662, 675, 683, 685, 696, 700, 711, 714, 717, 720, 730, 743, 749) (as *Eremaeus oblongus* in Luxton, 1987).
Genus *Tricheremaeus* Berlese, 1908
**Tricheremaeus serratus* (Michael, 1885) (as *Tricheremaeus serrata* in Luxton, 1987).

Superfamily Gustavioidea Oudemans, 1900

Family Astegistidae Balogh, 1961
Genus *Cultroribula* Berlese, 1908
^*Cultroribula bicultrata* Berlese, 1905 (740).
*^*C. juncta* (Michael, 1885) (624, 711).

Family Gustaviidae Oudemans, 1900
Genus *Gustavia* Kramer, 1979
*^*Gustavia microcephala* (Nicolet, 1855) (622, 686, 732).

Family Liacaridae Sellnick, 1928
Genus *Adoristes* Hull, 1916
^*Adoristes ovatus* (C.L. Koch, 1839) (617, 622, 623, 624, 625, 640, 641, 645, 647, 652, 667, 669, 683, 687, 689, 697, 701, 710, 711, 712, 713, 722, 724, 727, 731, 732, 737, 740, 741)
**A. poppei* (Oudemans, 1906)
Genus *Liacarus* Michael, 1898
^*Liacarus coracinus* (C.L. Koch, 1841) (669).
^*L. subterraneus* (C.L. Koch, 1841) (732).
Genus *Planoristes* Iturrondobeitia & Subías, 1978
†***Planoristes acuspidatus*** Iturrondobeitia & Subías, 1978 (633) (one specimen).
Distribution: Spain (Subías, 2019).
Genus *Xenillus* Robineau-Desvoidy, 1839
*^*Xenillus tegeocranus* (Hermann, 1804) (617, 621, 622, 626, 640, 645, 647, 672, 674, 682, 685, 687, 689, 691, 701, 711, 727, 732, 736, 740, 748, 749).

Family Peloppiidae Balogh, 1943
Genus *Ceratoppia* Berlese, 1908
*^*Ceratoppia bipilis* (Hermann, 1804) (619, 622, 623, 626, 632, 633, 636, 640, 645, 648, 652, 654, 656, 663, 666, 669, 671, 674, 678, 687, 689, 701, 706, 710, 713, 714, 715, 716, 719, 722, 724, 727, 740, 741, 748, 749).

Superfamily Carabodoidea C.L. Koch, 1837

Family Carabodidae C.L. Koch, 1837
Genus *Carabodes* C.L. Koch, 1835
^*Carabodes labyrinthicus* (Michael, 1879) (675, 681, 708, 731, 739, 749, 751).
*^*C. marginatus* (Michael, 1884) (624, 645, 661, 662, 671, 672, 680, 685, 699, 703, 720, 731, 734, 745, 749).
*^*C. willmanni* Bernini, 1975 (618, 624, 632, 635, 645, 660, 661, 662, 665, 668, 671, 672, 673, 677, 680, 685, 695, 703, 708, 730, 731, 733, 739, 741).
Genus *Odontocepheus* Berlese, 1913
*^*Odontocepheus elongatus* (Michael, 1879) (631, 640, 648, 656, 672, 706, 720, 727, 740, 741, 748).

Superfamily Oppioidea Grandjean, 1951

Family Autognetidae Grandjean, 1960
Genus *Autogneta* Hull, 1916
^*Autogneta parva* Forsslund, 1947 (749).

Family Oppiidae Grandjean, 1951
Genus *Berniniella* J. Balogh, 1983
^*Berniniella bicarinata* (Paoli 1908) (662, 663, 682).
*^*B. sigma* (Strenzke, 1951) (656, 689, 713, 746).
Genus *Dissorhina* Hull, 1916
*^*Dissorhina ornata* (Oudemans, 1900) (617, 618, 619, 620, 622, 624, 633, 634, 636, 637, 638, 640, 645, 647, 648, 649, 650, 651, 652, 654, 655, 661, 662, 663, 664, 665, 666, 667, 669, 671, 672, 674, 679, 680, 682, 685, 686, 687, 689, 690, 691, 694, 695, 700, 701, 703, 704, 705, 706, 707, 708, 709, 710, 711, 713, 714, 715, 716, 719, 721, 722, 725, 730, 734, 735, 736, 737, 741, 742, 743, 744, 748, 750).
Genus *Microppia* Balogh, 1983
^*Microppia minus* (Paoli, 1908) (650).

Genus _Multioppia_ Hammer, 1961

*^_Multioppia neglecta_ C. Pérez-Íñigo, 1969 (621, 622, 633, 654, 656, 663, 669, 672, 674, 680, 682, 685, 686, 687, 689, 691, 696, 706, 711, 716, 724, 727, 732, 737, 748).

Genus _Oppiella_ Jacot, 1937

Subgenus _Oppiella_ (_Moritzoppia_) Subías & Rodríguez, 1988

*^_Oppiella_ (_Moritzoppia_) _keilbachi_ (Moritz, 1969) (618, 652, 654, 662, 706, 711, 735, 749) (as _Moritziella keilbachi_ in Luxton, 1987).

*^_O._ (_M._) _neerlandica_ (Oudemans, 1900) (617, 619, 622, 623, 629, 631, 632, 636, 640, 645, 648, 652, 655, 664, 666, 669, 685, 694, 700, 710, 725, 742, 744, 748, 750) (as _Lauroppia neerlandica_ in Luxton, 1987).

*^_O._ (_M._) _unicarinata_ (Paoli, 1908) (635, 645, 664, 672, 729, 734, 735) (as _Moritziella unicarinata_ in Luxton, 1987).

Subgenus _Oppiella_ (_Oppiella_) Jacot, 1937

^_Oppiella_ (_Oppiella_) _falcata_ (Paoli, 1908) (706).

^ _O._ (_O._) _maritima_ (Willmann, 1929) (644, 661, 748, 749).

*^_O._ (_O._) _nova_ (Oudemanns, 1902) (616, 623, 624, 638, 648, 654, 662, 663, 664, 665, 671, 682, 703, 706, 724, 741, 748) (as _Oppiella nova_ in Luxton, 1987).

^_O._ (_O._) _propinqua_ Mahunka & Mahunka-Papp, 2000 (631, 725).

†**_Oppiella (Oppiella) splendens_** (C.L. Koch, 1841) (630, 634, 668, 699, 700, 703, 720, 729, 735, 749) (numerous specimens).

Distribution: Holarctic (Weigmann, 2006) and Australia (Subías, 2019).

Subgenus Oppiella (_Rhinoppia_) Balogh, 1983

*^_Oppiella_ (_R._) _obsoleta_ (Paoli, 1908) (617, 640, 748) (as _Medioppia obsoleta_ in Luxton, 1987).

^_O._ (_R._) _subpectinata_ (Oudemans, 1900) (619, 622, 633, 640, 645, 648, 649, 663, 664, 666, 669, 677, 680, 689, 694, 695, 696, 705, 706, 710, 713, 716, 719, 722, 736, 740, 741, 746, 748).

Genus _Ramusella_ Hammer, 1962

^_Ramusella assimilis_ (Mihelčič, 1956) (671, 731, 741).

^_R. clavipectinata_ (Michael, 1885) (650, 663, 667, 669, 671, 672, 674, 680, 682, 727, 731).

^_R. elliptica_ (Berlese, 1908) (626, 633, 663, 665, 672, 674, 709, 731).

^_R. insculpta_ (Paoli, 1908) (674, 687).

Genus _Serratoppia_ Subías & Mínguez, 1985

†**_Serratoppia serrata_** (Mihelčič, 1956) (663, 682, 689) (three specimens).

Distribution: Western Palaearctic (except North) and Venezuela (Subías, 2019).

Family Quadroppiidae Balogh, 1983

Genus _Coronoquadroppia_ Ohkubo, 1995

Note: The genus _Coronoquadroppia_ Okhubo, 1995 was not regarded by Weigmann (2006) as being sufficiently distinct from _Quadroppia_ Jacot, 1939, but was accepted by that author in a subsequent publication (Weigmann, 2010).

*^_Coronoquadroppia galaica_ Mínguez, Ruis & Subías, 1985 (624, 633, 638, 656, 672, 680, 689, 706, 711, 713, 727, 737, 744, 748) (as _Quadroppia bellula_ in Luxton, 1987).

^_C. monstruosa_ (Hammer, 1979) (721).

^_C. pseudocircumita_ Mínguez, Ruis & Subías, 1985 (638, 706, 740, 746).

Genus _Quadroppia_ Jacot, 1939

*^_Quadroppia maritalis_ Lions, 1982 (633, 638, 640, 706, 713, 741, 746).

*^_Q. quadricarinata_ (Michael, 1885) (618, 619, 628, 642, 646, 689, 690, 696, 702, 708, 709, 713, 721, 734, 735, 744, 746, 747, 749).

Family Thyrisomidae Grandjean, 1953

Genus _Banksinoma_ Oudemans, 1930

*^_Banksinoma lanceolata_ (Michael, 1885) (619, 624, 629, 633, 645, 648, 654, 656, 661, 662, 669, 672, 680, 687, 689, 693, 694, 701, 705, 710, 713, 716, 722, 727, 731, 737, 744).

Genus _Pantelozetes_ Grandjean, 1953

†**_Pantelozetes berlesei_** Fujikawa, 1979 (622) (one specimen).

Distribution: Southwestern Europe (Subías, 2019).

^_P. paolii_ (Oudemans, 1913) (622, 651, 669, 678, 682).

Superfamily Trizetoidea Ewing, 1917

Family Suctobelbidae Jacot, 1938

Genus _Suctobelba_ Paoli, 1908

^_Suctobelba regia_ Moritz, 1970 (634, 638, 699, 701, 710, 729, 735, 748) (eight specimens).

*^_S. trigona_ (Michael, 1888) (618, 628, 633, 638, 641, 644, 648, 649, 672, 680, 682, 689, 710, 711, 712, 721, 737, 742, 744, 747, 748, 749).

Genus _Suctobelbella_ Jacot, 1937

^_Suctobelbella acutidens_ (Forsslund, 1941) (617, 618, 633, 638, 648, 654, 656, 663, 672, 682, 687, 689, 691, 706, 709, 712, 723, 732, 737, 742, 744, 748, 751).

^_S. arcana_ Moritz, 1970 (707, 740, 746, 751).

^_S. falcata_ (Forsslund, 1941) (706).

^_S. hamata_ Moritz, 1970 (706, 737).

*^_S. nasalis_ (Forsslund, 1941) (633, 689, 727, 732, 740, 749).

^ _S. perforata_ (Strenzke, 1950) (648, 751).

*^_S. sarekensis_ Forsslund, 1941 (618, 645, 689, 671, 706, 713, 737, 748).

^_S. similis_ (Forsslund, 1941) (648, 652, 689, 746, 748, 751).

*^_S. subcornigera_ (Forsslund, 1941) (633, 638, 645, 648, 656, 663, 665, 669, 672, 680, 682, 685, 689, 703, 706, 707, 709, 711, 713, 722, 727, 737, 740, 742, 744, 748, 749, 751).

^_S. subtrigona_ (Oudemans, 1916) (625, 633, 663, 689, 709, 737, 740).

*_S. vera_ (Moritz, 1964).

†**_Suctobelbella_** sp. (unidentified) (648) (one specimen).

Distribution: not applicable.

Superfamily Tectocepheoidea Grandjean, 1954

Family Tectocepheidae Grandjean, 1954

Genus *Tectocepheus* Berlese, 1895
*^*Tectocepheus velatus* (Michael, 1880) (618, 620, 623, 627, 648, 651, 661, 665, 668, 671, 674, 680, 682, 691, 693, 696, 698, 703, 707, 709, 712, 713, 723, 731, 737, 742, 744, 748, 751).
†***Tectocepheus velatus alatus*** Berlese, 1913 (617, 622, 624, 638, 641, 662, 672, 690, 694, 702, 706, 710, 711, 714, 727, 741, 745, 746, 747) (numerous specimens).
Distribution: Palaearctic (Weigmann, 2006).

Superfamily Ameronothroidea Willmann, 1931

Family Ameronothridae Willmann, 1931
Genus *Ameronothrus* Berlese, 1896
^*Ameronothrus lineatus* (Thorell, 1871) (679).
^*A. maculatus* (Michael, 1882) (617, 643, 644, 658, 659, 664, 681, 684, 697, 708, 717, 728, 730, 736, 739, 749).
*^*A. marinus* (Banks, 1896) (679) (as *Hygroribates marinus* in Luxton, 1987).
^*A. schneideri* (Oudemans, 1903) (679).

Superfamily Licneremaeoidea Grandjean, 1954

Family Licneremaeidae Grandjean, 1954
Genus *Licneremaeus* Paoli, 1908
^*Licneremaeus licnophorus* (Michael. 1882) (618).

Family Scutoverticidae Grandjean, 1954
Genus *Scutovertex* Michael, 1879
*^*Scutovertex sculptus* Michael, 1879 (624, 635, 653, 665, 667, 673, 676, 680, 681, 685, 690, 695, 696, 698, 717, 731, 733, 735, 747).

Superfamily Phenopelopoidea Petrunkevich, 1955

Family Phenopelopidae Petrunkevich, 1955
Genus *Eupelops* Ewing, 1917
^*Eupelops acromios* (Hermann, 1804) (709).
^*E. hirtus* (Berlese, 1916) (647).
^*E. plicatus* (C.L. Koch, 1839) (621, 624, 625, 709, 677, 682, 711, 731, 743).
^*E. tardus* (C.L. Koch, 1835) (644, 667, 732).
^*E. torulosus* (C.L. Koch, 1839) (640).
Genus *Peloptulus* Berlese, 1908
^*Peloptulus phaeonotus* (C.L. Koch, 1844) (624, 650, 663, 665, 674).

Superfamily Achipterioidea Thor, 1929

Family Achipteriidae Thor, 1929
Genus *Achipteria* Berlese, 1885
*^*Achipteria coleoptrata* (Linnaeus, 1758) (617, 644, 663, 671, 682, 721, 732).
^*A. nitens* (Nicolet, 1855) (623).
Genus *Parachipteria* van der Hammen, 1952
^*Parachipteria punctata* (Nicolet, 1855) (623, 630, 631, 638, 664, 680, 700, 704, 711, 719, 723, 726, 729, 735, 742, 744, 749).
* *P. willmanni* van der Hammen, 1952.
Genus *Pseudachipteria* Travé, 1960
^*Pseudachipteria magna* (Sellnick, 1928) (628, 634, 635, 643, 672, 680, 681, 683, 689, 700, 720, 731, 733, 734, 735, 748, 749).

Superfamily Oribatelloidea Jacot, 1925

Family Oribatellidae Jacot, 1925
Genus *Joelia* Oudemans, 1906
^*Joelia fiorii* (de Coggi, 1898) (622, 640, 740).
Genus *Ophidiotrichus* Grandjean, 1953
^*Ophidiotrichus tectus* (Michael, 1884) (619, 623, 636, 649, 672, 677, 691, 700, 707, 724, 736, 741).
Genus *Oribatella* Banks, 1895
^*Oribatella quadricornuta* (Michael, 1880) (647, 654, 674, 680, 686, 687, 689, 691, 696, 711, 731, 736, 743).

Superfamily Oripodoidea Jacot, 1925

Family Oribatulidae Thor, 1929
Genus *Oribatula* Berlese, 1895
†***Oribatula longilamellata*** Schweizer, 1956 (680) (one specimen).
Distribution: Central Western Europe (Subías ,2019); Switzerland, Poland, Germany (Weigmann, 2006).
^*O. tibialis* (Nicolet, 1855) (617, 621, 624, 625, 640, 650, 656, 660, 662, 663, 667, 671, 672, 674, 676, 682, 685, 709, 715, 724, 733, 741, 749).
Genus *Phauloppia* Berlese, 1908
*^*Phauloppia lucorum* (C.L. Koch, 1841) (620, 629, 640, 644, 654, 659, 673, 675, 681, 684, 685, 690, 698, 714, 721, 728, 730, 731, 733, 739, 747, 749, 751).
Note: Luxton (1987) listed *Phauloppia longiporosa* as resident in the Isle of Man, but it is known to be a synonym of *P. lucorum* (Weigmann, 2006).
Genus *Zygoribatula* Berlese, 1916
*^*Zygoribatula exilis* (Nicolet, 1855) (699, 721, 729).
**Z. knighti* Luxton, 1987 (subsequently found at Talacre Dunes, Wales: Monson, 2000).
†***Zygoribatula propinqua*** (Oudemans, 1900) (696) (one specimen).
Distribution: Palaearctic (Weigmann, 2006).

Family Scheloribatidae Grandjean, 1933
Genus *Liebstadia* Oudemans, 1906
^*Liebstadia longior* (Berlese, 1908) (695).
Note: Previously listed in Luxton (1996) as *Protoribates badensis*; see also Miko & Weigmann (1996).
*^*L. similis* (Michael, 1888) (619, 624, 627, 636, 638, 648, 650, 651, 655, 657, 661, 663, 666, 667, 669, 679, 680, 682, 685, 686, 689, 693, 697, 703, 708, 709, 710, 711, 719, 722, 727, 731, 732, 736, 747).
Genus *Scheloribates* Berlese, 1908
Subgenus *Scheloribates* (*Hemileius*) Berlese, 1916
^*Scheloribates* (*Hemileius*) *initialis* (Berlese, 1908) (617, 621, 622, 627, 638, 662, 663, 674, 680, 682, 693, 732).
Subgenus *Scheloribates* (*Scheloribates*) Berlese, 1908
^*Scheloribates* (*Scheloribates*) *ascendens* Weigmann & Wunderle, 1990 (633, 643, 644, 659, 673, 679, 684, 717, 728).
*^*S.* (*S.*) *laevigatus* (C.L. Koch, 1836) (624) (as *Scheloribates laevigatus* in Luxton, 1987).

^_S._ (_S._) _latipes_ (C.L. Koch, 1844) (616, 672, 680, 731).
†**_Scheloribates_ (_Scheloribates_) _minifimbriatus_** Mínguez, Subías & Ruis, 1986 (704) (one specimen).
Distribution: Mediterranean and North Carolina, U.S.A. (Subías, 2019); Portugal (Weigmann, 2010).

Superfamily Ceratozetoidea Jacot, 1925

Family Ceratozetidae Jacot, 1925
Genus _Ceratozetes_ Berlese, 1908
†**_Ceratozetes conjunctus_** Mihelčič, 1956 (704) (one specimen).
Distribution: Southern Palaearctic (Mediterranean area and Iran) (Subías, 2019).
^_C. gracilis_ (Michael, 1884) (617, 632, 663, 678, 682, 689, 694, 703).
*^_C. peritus_ Grandjean, 1951 (617, 621, 622, 626, 640, 664, 691, 693, 697, 703, 711, 732, 740, 748).
†**_Ceratozetes_** sp. (unidentified) (672) (four specimens).
Distribution: not applicable.
Genus _Edwardzetes_ Berlese, 1914
*^_Edwardzetes edwardsi_ (Nicolet, 1855) (619, 624, 638, 641, 648, 664, 677, 693, 694, 704, 726, 742, 746).
Genus _Fuscozetes_ Sellnick, 1928
*^_Fuscozetes fuscipes_ (C.L. Koch, 1844) (655).
Genus _Melanozetes_ Hull, 1916
^_Melanozetes mollicomus_ (C.L. Koch, 1839) (624, 630, 638, 664, 683, 703, 704, 709, 715, 726, 735, 742, 744, 749).
^_M. stagnatilis_ (Hull, 1914) (664, 742).
Genus _Sphaerozetes_ Berlese, 1885
^_Sphaerozetes piriformis_ (Nicolet, 1855) (628, 634, 635, 700, 704, 711, 734, 735, 742, 749).
*_S. orbicularis_ (C.L. Koch, 1835).
Genus _Trichoribates_ Berlese, 1910
^_Trichoribates berlesei_ Jacot, 1929 (618, 625, 643, 644, 646, 686, 689, 698).
(= _T. trimaculatus sensu_ Sellnick 1928 (Weigmann, 2006)).
*^_T. incisellus_ (Kramer, 1897) (667, 669, 685, 686, 727, 738, 743) (as _Latilamellobates incisellus_ in Luxton, 1987).
^_T. novus_ (Sellnick, 1928) (647, 685, 686, 743).

Family Chamobatidae Grandjean, 1954
Genus _Chamobates_ Hull, 1916
*^_Chamobates borealis_ (Trägårdh, 1902) (624, 648, 706, 710, 711, 713, 737).
*^_C. cuspidatus_ (Michael, 1884) (630, 720, 634, 641, 646, 672, 678, 685, 693, 701, 720, 734).
^_C. interpositus_ Pschorn-Walcher, 1953 (706, 710, 739).
^_C. pusillus_ (Berlese, 1895) (618, 619, 622, 623, 625, 627, 630, 631, 632, 633, 636, 637, 638, 639, 640, 645, 647, 649, 651, 652, 654, 656, 661, 662, 664, 670, 672, 674, 677, 680, 682, 683, 685, 690, 694, 695, 699, 704, 705, 707, 710, 712, 713, 714, 716, 719, 720, 721, 722, 724, 727, 729, 731, 737, 739, 740, 741, 742, 743, 749).
Genus _Ocesobates_ Aoki, 1965
^_Ocesobates tumidisetosus_ (Monson, 2002) (648, 734)
Note: This species was referred to as _Chamobates tumidisetosus_ by Monson (2002); Subías (2019) placed it in _Ocesobates_.

Family Euzetidae Grandjean, 1954
Genus _Euzetes_ Berlese, 1908
*^_Euzetes globulus_ (Nicolet, 1855) (617, 621, 622, 626, 634, 638, 640, 655, 666, 677, 682, 688, 691, 695, 697, 706, 711, 715, 734, 748).
Note: This species is generally referred to as _E. globulus_. However, as Hull (1920) has pointed out, _E. nitens_ (Johnston, 1853), being earlier, should take precedence. The even earlier nomenclature suggested by some authors - _E. seminulum_ (O.F. Müller, 1776) - has been dismissed by van der Hammen (1952) as being insufficiently founded (Luxton, 1990c).

Family Humerobatidae, Grandjean, 1971
Genus _Humerobates_ Sellnick, 1928
*_Humerobates rostrolamellatus_ Grandjean, 1936.

Family Punctoribatidae Thor, 1937 (= Mycobatidae Grandjean, 1954)
Genus _Minunthozetes_ Hull, 1916
^_Minunthozetes semirufus_ (C.L. Koch, 1841) (687, 716, 737, 739).
Genus _Mycobates_ Hull, 1916
^_Mycobates parmeliae_ (Michael, 1884) (644, 673, 684).
Genus _Punctoribates_ Berlese, 1908
^_Punctoribates punctum_ (C.L. Koch, 1839) (638, 674, 739, 747).
Genus _Zachvatkinibates_ Shaldybina, 1973
^_Zachvatkinibates quadrivertex_ (Halbert, 1920) (679) (as _Punctoribates quadrivertex_ in Luxton, 1996).

Superfamily Galumnoidea Jacot, 1925

Family Galumnidae Jacot, 1925
Genus _Acrogalumna_ Grandjean, 1956
^_Acrogalumna longipluma_ (Berlese, 1904) (617, 621, 622, 626, 640, 697, 701, 711, 715, 731, 732, 740, 748).
Genus _Pergalumna_ Grandjean, 1936
^_Pergalumna altera_ (Oudemans, 1915) (622).

DISCUSSION

Representatives of 172 species, one subspecies, 85 genera and 40 families have now been recorded from the Isle of Man. Included in the list is a species of _Suctobelbella_ Jacot, 1937 and another of _Ceratozetes_ Berlese, 1908 that are as yet unidentified and possibly new to science. All other species and subspecies found new to Britain in this collection are also recorded for mainland Europe (Weigmann, 2006; Subías, 2019).

The original collections made in the Isle of Man (Luxton, 1987) suggested that the oribatid fauna in this location is rather unusual. For instance, several of the new British records from there (e.g. _Zygoribatula knighti_, subsequently collected in Freshwater West, Dyfed (Luxton, 1987; Monson, 2000)) resemble more closely the fauna of the Iberian peninsula (and further east) than those of the rest of Britain. The Isle of Man is known to have been glaciated at the time of the last Ice Age (Manx Geological Society, 2020); whether species could have survived the glaciation is debatable. Due to under-recording, Mediterranean and eastern species may be more widely distributed across Western Europe than previously realised; the oribatid fauna of the Mediterranean region itself has been much better studied. However, it is also possible that transport through anthropogenic mechanisms (e.g. shipping) or some form of natural spread associated with climate change may be responsible for the appearance of these species.

The Isle of Man appears to have a very high species richness in comparison with other islands and archipelagos of the British Isles: Shetland, 100 (Monson, 2014); Orkney, 36 (Luxton, 1989); Holy Island (Northumberland), 15 (Luxton, 1990a); Jersey (Channel Isles), 67 (Luxton, 1990b); and Scilly Isles, 44 (Luxton, 1990c). The five most speciose families were Oppiidae (20 species), Brachychthonidae (16), Suctobelbidae (14), Ceratozetidae (13) and Euphthiracaridae (eight). The five most species-rich samples were 689 (Cass-ny-Hawin Head, gorse litter: 30 species), 649 (Tholt-e-Will Glen, heather litter: 29), 627 (Laxey Glen Gardens, beech litter: 28), 648 (Tholt-e-Will Glen, moss: 25) and 617 (The Raggett, larch litter: 21). The list will probably be incomplete since large areas of the island were not searched by M.L. (see Fig.1). In addition, samples were of fairly small size, each amounting to just a few handfuls of material. It might be useful for a future collector on the Isle of Man to visit farms (the older the better), particularly farm buildings and dutch barns containing damp hay and/or rotting straw. In this habitat on the mainland F.D.M. has found interesting species new to Britain, *viz. Baioppia (Lalmoppia) talacrensis* (Monson, 2000), *Epidamaeus* cf. *floccusus* (Behan-Pelletier and Norton, 1985), *Haplozetes vindobonensis* (Willmann, 1935) and *Oppia denticulata* (R. & G. Canestrini, 1882) (Monson, in prep.).

The success of this survey will, it is hoped, be a stimulus for future work on the Isle of Man and elsewhere, with a view to furthering our knowledge of oribatids within a European context.

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SHORT NOTES

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Native oyster (*Ostrea edulis* L, 1758) on Great Cumbrae Island, Scotland

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On 31st March 2019 I came across an isolated, living specimen of the native oyster (*Ostrea edulis*) at Ballochmartin Bay, Great Cumbrae Island (NS570182) (Fig. 1), which, after being photographed, was rapidly replaced *in situ*. I record this observation since in 40 or more years of taking student classes onto local beaches, I can recall only one other time (date unrecorded) that another live oyster was previously found on the same beach.

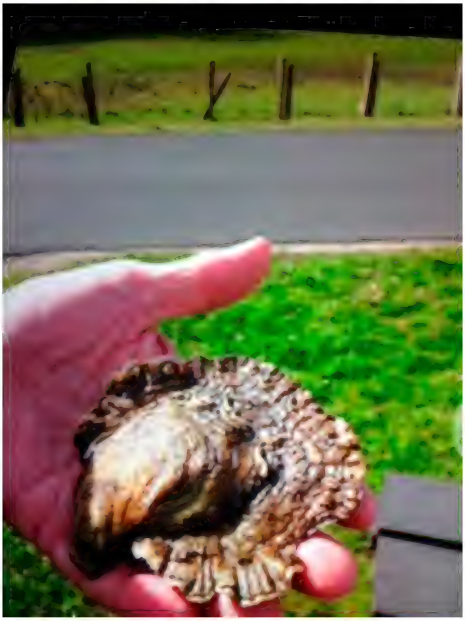

Fig. 1. A live oyster (*Ostrea edulis*) at Ballochmartin Bay, Great Cumbrae, Scotland, 31st March 2019. (Photo: J. Moore)

Allen (1962) reported that, except for Loch Ryan, in the Clyde Sea Area the species was scarce, represented by only remnants of cultivated oyster beds, among which he mentioned "Balloch Bay", likely referring to Ballochmartin Bay. In Chapter XIII of *Millport and the Cumbraes* (Campbell, 1975), which I contributed to, I noted the following: "Oysters, once introduced in Balloch Bay, are now conspicuous by their absence". Dr Richard B. Pike began research on oysters from Millport in 1946, primarily in two arms of Loch Sween (Kyle Scotnish and Linne Mhuirich) but also at Easdale Quarry (Argyll). That work was continued by Dr Robin H. Millar. In May 1950 a large outdoor reinforced concrete tank was built for oyster research across the road from the then Scottish Marine Biological Association's Marine Station and in 1961 the ex-naval buildings at Keppel Point were fitted out as an oyster hatchery for Dr Michael Droop (Marshall, 1987). However, I can find no mention, in any of the Annual Reports of the Scottish Marine Biological Association from 1946 up to 1970, of Ballochmartin Bay being a deliberate oyster laying site, and so the history of any "cultivated oyster bed" there must be distant.

Times have changed markedly since Macdonald (1857) could comment glibly: "Passing Balloch Bay, where a board of oysters may be procured at certain states of the tide". That casual comment suggests that in the 19th century Ballochmartin Bay supported a natural bed of native oysters. My latest finding calls to mind another recent report of a find of "extinct" oysters (two live individuals) in the Firth of Forth, beds that once supported a huge fishery (Anonymous, 2009). Presumably what we witness on Cumbrae today is another historic example of a native oyster bed overexploited to effective extinction. The native oyster formed part of Scottish Natural Heritage's Species Action Framework, with an objective to attempt restoration of oyster populations in areas where they were previously abundant (Gaywood *et al.*, 2016). Might efforts to restore Firth of Forth populations also be applicable to Cumbrae?

There is considerable interest Europe-wide at present in the restoration of native oyster beds, as witness the Native Oyster Restoration Alliance (NORA) (see https://noraeurope.eu) and a research project is currently being run by Heriot-Watt University in conjunction with The Marine Conservation Society and Glenmorangie Distillery with a view to the restoration of native oysters in the Dornoch Firth, Highland (D. Donnan, pers. comm.). The native oyster is a Priority Marine Feature under the National Marine Plan such that no damage may be done to a native oyster bed. There are anecdotal reports that small pockets of native oysters might exist at the head of Loch Riddon and Loch Striven, Argyll (A. Forbes, pers. comm.). Indeed it seems likely that all the Clyde sea lochs might once have held native oyster populations at their heads. Such populations are known from Campbeltown Loch, Loch Tarbert and possibly Loch Fyne (all Argyll), although the last requires confirmation (D. Donnan, pers. comm.).

Intriguing questions remain. How old might the Ballochmartin Bay 2019 individual be? Native oysters may live up to 15 years, although six years is more usual (University Marine Biological Station Millport, 2007). Whence might any remaining local spawning stock originate? David Donnan informed me that he found a small population (40 or so individuals) of native oysters living on Southannan sands (North Ayrshire), on the mainland opposite to Cumbrae, that were associated with slightly elevated patches of mussel (*Mytilus edulis*) beds, and that the population contained individuals of a range of sizes. This then may be the origin of a larva reaching Ballochmartin Bay on Cumbrae, where a range of shelly ground provides potential cultch, the material comprising oyster grounds.

Pacific oysters (*Crassostrea gigas*), brought in as juveniles, are reared commercially at Portencross on the adjacent mainland but are non-spawning and held in enclosed tanks with escapees being highly unlikely (A. Forbes, pers. comm.).

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D.S. Raitt (1903–1944): a premature loss to Scottish fisheries research

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Douglas Stewart Raitt (1903–1944) was born in Aberdeen on 18th January 1903, the son of John Raitt a chemical works manager, and educated at Robert Gordon's College, Aberdeen (Russell, 1945). A triple graduate of the University of Aberdeen (B.Sc. 1926; Ph.D. 1930; D.Sc. 1937), he married Jane Ferrier on 2nd November 1932 (Mackintosh, 1960). Before the Second World War, he served on the staff of the Marine Laboratory of the Fishery Board for Scotland, Aberdeen. He was elected a Fellow of the Linnean Society of London on 7th March 1935, his application supported by three influential signatories: William Thomas Calman FRSE, FRS (1871–1952), Stanley Wells Kemp FRS (1882–1945) and Isabella Gordon OBE (1901–1988). Elected a Fellow of the Royal Society of Edinburgh in 1936 he was appointed Buckland lecturer for 1940, although the outbreak of war prevented his delivery of the projected series of lectures on his specialist focus - the haddock (*Melanogrammus aeglefinus*) (Russell, 1945), and he was seconded to the Home Security Department and appointed assistant for the Highlands. Later, he went on to hold a similar post in the Edinburgh and South-east of Scotland area, ending-up as principal assistant to District Commissioner Sir John Phin (1881–1955) (Anonymous, 1944).

A man of many parts, he was also a writer of plays and songs. He wrote one of the productions of the University of Aberdeen Students' Gala weeks (Raitt, 1933a) - annual events featuring musical, theatrical and comedic elements held since 1921. The 1933 show was re-written extensively and presented in its new form for a week in September 1934 to coincide with the third visit to Aberdeen of the British Association for the Advancement of Science. Raitt directed these shows in 1931, 1933–1934 and 1938–1939, and participated therein as “Rab the Rhymer.” A popular performer, singing to his own piano accompaniment, he broadcast on the BBC from its Aberdeen studio.

Tragically he was fatally injured in an accident at his home, Thriepley House, Lundie, Angus on 4th October 1944 while attempting to start a car, when it moved off and ran over him (Anonymous, 1944). He left a wife and two children*. Russell (1945) averred that “all deplore that early death should have cut short the brilliant career opening before him.” Marine science has been blighted by car accidents: Sir John Murray KCB, FRS (1841–

1914) was killed when his motor car overturned near his home in Edinburgh, and Edward Flanders Robb "Ed" Ricketts (1897–1948) was killed when a passenger train hit his car in Monterey, California.

The haddock was central to Raitt's professional career. Curing haddock by smoking had become commonplace in Scotland by 1830. Fish were split so as to lie flat, then smoked over a peat fire - a method that originated at Findon in Scotland and was widely copied (Gray, 1978). In Aberdeen such fish, smoked with turf, were called Finnan haddies, the product being taken by coach and sea to Edinburgh and Glasgow and by steamship to London. These and Arbroath smokies, another form of smoked haddock, remain a Scottish delicacy. Of course fresh haddock was consumed in Scotland and no small part in its promotion was played by immigrant Italians who opened fish-and-chip shops, first in Glasgow then in Edinburgh and elsewhere: between 1890 and 1914 their number increased from 750 to 4,500 (Coull, 2008).

Howell (1921) devoted a chapter in his book *Ocean Research and the Great Fisheries* to what he called "the haddock problem." He noted that "about 71.8 per cent of haddock came from the North Sea and they formed about 45.1 per cent of the North Sea catch in 1906." Between 1906 and 1913 there was a serious "decline" in North Sea haddock that may have been a result of natural fluctuations, something to which the species is prone (due to disparate numbers of juveniles entering the population in different years: Adams, 1996; Gulland, 1970), rather than the impact of steam trawling. Howell (1921) noted that the Norwegians had been collecting data bearing on the life-history of the species and felt that "British naturalists ought to be in close touch with all haddock investigations." Raitt's work on the bionomics of the North Sea haddock (Raitt, 1930, 1933b, 1936, 1937a, 1939) was therefore most apposite in investigating the biology of this species which by that time ranked alongside the herring as the most significant food-fish in Scotland (Adams, 1996). Haddock investigations had been initiated in Aberdeen by the then Scientific Superintendent (later Director) of the Marine Laboratory, Dr Alexander Bowman (1876–1941), and brilliantly executed by Dr Harold Thompson (1890–1957) (see references in Hardy, 1959). When Thompson left for Newfoundland, Raitt was given charge of the haddock work (Russell, 1944).

Supplementing his haddock researches, Raitt published two papers on amphipod crustaceans (Raitt, 1929, 1937b), both bearing on fishery issues. Benthic Amphipoda play an important role as a source of demersal fish food, indeed Raitt's 1937b paper was based partly on an analysis of haddock stomach contents and partly on benthic sampling using a Petersen grab. Raitt's 1929 paper, which confirmed earlier observations (Faulkner, 1925), referred to dead cod (*Gadus morhua*) with no outwards sign of infestation whose ovaries were being consumed by scavenging lysianassid amphipods *Tmetonyx cicada*; these appeared to have entered via the oviducts probably after the cod had died when bad weather delayed hauling of ground nets.

Away from haddock, as a side-line Raitt turned his attention to sandeels (Russell, 1944). The belief that there were only three species of sandeel in U.K. waters, *viz. Hyperoplus lanceolatus*, *Ammodytes tobianus* and *Gymnammodytes semisquamatus*, continued until 1934 when Raitt discovered a fourth, deeper-water, species named now after its discoverer as Raitt's sandeel (*A. marinus*) and known also as the small sandeel. (A fifth species, *H. immaculatus*, was discovered in 1950: see https://britishseafishing.co.uk/Greater-and-lesser-sandeel/).

I am grateful to Lynda Brooks (Linnean Society of London) and Helen McGregor (Marine Scotland Science) for information received.

*Raitt's son, Douglas Ferrier Stewart Raitt, born in 1935, followed in his father's footsteps as a fishery scientist, obtaining a Ph.D. for research on the norway pout (*Trisopterus esmarkii*) from the University of Aberdeen in 1967 and subsequently working at the Marine Laboratory, Aberdeen and at the Food and Agriculture Organisation in Rome.

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The leech *Glossiphonia verrucata* (Hirudinea: Glossiphoniidae) in Scotland

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Historically, there are relatively few records of the leech *Glossiphonia verrucata* (F. Müller, 1844) from the British Isles. Johnston (1865) first reported a specimen in the British Museum (Natural History) collections from Cobham, Surrey. However Mann (1953) re-examined the specimen and found the identification to be incorrect. McCarthy (1975) reported *G. verrucata* from the River Camlin in County Longford, Ireland and Elliott and Mann (1979) reported that the species was also known from England but did not give any records. However, this note may relate to a specimen in the Freshwater Biological Association collection from the River Soar at Birstall, Leicestershire, collected in 1958 (McCloskey & Elliott, 2001). Elliott & Tullet (1982) provide two additional records from Oxfordshire and Essex. The Environment Agency first recorded *G. verrucata* from the River Rea near Edgbaston in 1988 and since then has recorded it across much of England, particularly the Midlands, East Anglia and Lincolnshire (Fig. 1). Sampling by the Scottish Environment Protection Agency has not recorded this species from Scotland (Ian Lorimer, pers. comm.).

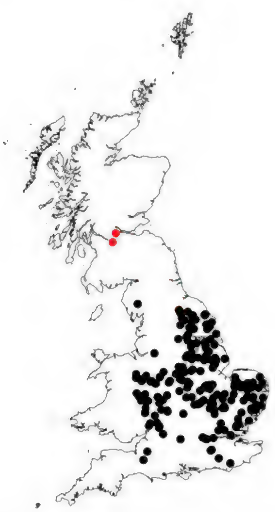

Fig. 1. Distribution of records of the leech *Glossiphonia verrucata* in Great Britain (red dots = recent Scottish records discussed herein). Source of data: Environment Agency.

The first Scottish record of *G. verrucata* was from Strathclyde Loch, South Lanarkshire (NS7257), and was a single specimen found by S.D. during monitoring before the use of the loch for a triathlon event in 2016. The loch was used again for the European Championships in 2018 and the leech was recorded by S.D. from several locations in its southern basin and also in the River Clyde immediately downstream of the loch outlet. The habitat was silt over man-made substrate.

More recently a second specimen of *G. verrucata* was collected by A.L. and J.L. while sampling for freshwater molluscs in the Forth and Clyde Canal at Lock 17 near Underwood, Stirlingshire (NS8057179007) on 6th December 2018. The canal here is approximately 20 m wide and fringed with reed sweet-grass (*Glyceria maxima*) (Fig. 2). The canal was accessed from the towpath on the north bank, where a floating pontoon is located immediately east of the canal lock. Submerged vegetation was swept with a telescopic pond net (240 x 300 mm frame; handle 82 cm collapsed, 125 cm extended; 1 mm mesh net). The resultant catch was transferred to a white tray where a single specimen of *G. verrucata* was found (Fig. 3). Other macro-invertebrates present included the water hog-louse *Asellus aquaticus*, the freshwater snails *Lymnaea stagnalis*, *Radix balthica*, *Physa fontinalis* and *Planorbis* sp., the caddisflies *Holocentropus dubius* and *Limnephilus* sp., and the non-native shrimp *Crangonyx pseudogracilis*.

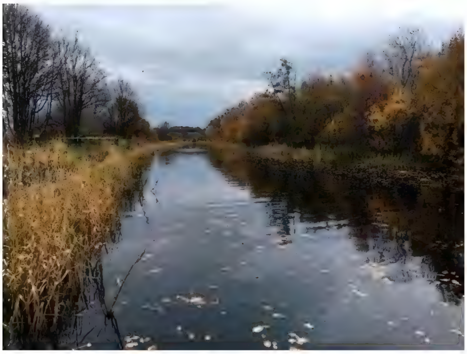

Fig. 2. Forth and Clyde Canal at Underwood, Stirlingshire, Scotland. (Photo: C. Macadam)

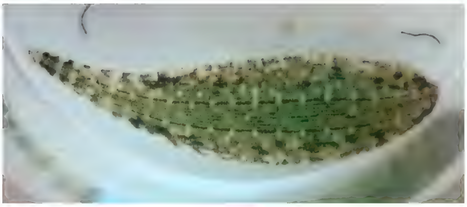

Fig. 3. Specimen of the leech *Glossiphonia verrucata* collected at Underwood, Stirlingshire, Scotland. The animal was 18 mm long. (Photo: C. Macadam)

Whether *G. verrucata* is an overlooked British species or an introduced non-native species is difficult to ascertain. The paucity of records in the U.K. prior to the 1970s suggests that it is a recent introduction to British waters, although the lack of attention given to freshwater leeches in general means that it is likely under recorded. The relatively recent expansion in the distribution of records in England could signify the spread of a non-native species, and certainly the discovery of this species in Scotland, some 290 km north of the nearest English record suggests that it may have been introduced accidentally, perhaps on the hull of a boat. The Forth and Clyde Canal was re-opened to boat traffic in 2001 and Strathclyde Loch has been used for international water sports events for several decades.

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The Faroe Islands Expedition, 1979: the usefulness of class reunions

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A list of all University of Glasgow Exploration Society expeditions, focussing on their natural history interest, was compiled by Downie *et al.* (2018), from the first known (Canna, 1936) to the most recent. Glasgow Natural History Society has been a major supporter of these expeditions since the beginning of the Blodwen Lloyd Binns Bequest (Downie *et al.*, 2012). One of the sources of information on past expeditions was the Carnegie Trust for the Universities of Scotland which supplied records for all the expeditions which they had supported financially. In a few cases, the Carnegie grant was the only information available, since no expedition report had been deposited, as was the norm, in the University of Glasgow Library. One of those without any report was the expedition to the Faroe Islands in 1979.

In September 2019, the Zoology (and related subjects) class which completed their studies in 1979 held a class reunion, to celebrate 40 years since graduation. Roger Downie, along with several colleagues, was invited to attend and to give a short presentation. He talked about the development of the Exploration Society since their time, and happened to mention the missing Faroes report: did any of those attending the reunion know anything about it? Eyes lit up: three of them had been on the expedition and remembered many of the others who had participated. Some had good recollections of what they had done, and some even had photographs and other relevant material in their lofts.

The overall leader and instigator was Malcolm Beveridge, who had been completing his Ph.D. at the time, which explains the lack of a final report. Malcolm went on to an international career in fisheries and aquaculture, but is now back in Scotland, and was easily contacted via Colin Adams. Malcolm was very willing to contribute to a summary report from memory. Another team member, a junior honours level undergraduate in 1979, and now a senior staff member at SEPA and GNHS Council member, was Myles O'Reilly. He was also able to provide some details and photographs, partly with the help of another team member, Matthew Service, an ecologist working at the Agri-Food and Biosciences Institute in Northern Ireland. Another contributor to this article is Lesley Wiseman-Orr: Lesley was at the class reunion, and was able to find various records of the expedition, including her daily diary, which she has allowed to be copied for the Exploration Society archives. Lesley has enjoyed a varied career in publishing, science and education, and is currently an honorary research fellow and tutor in the University of Glasgow. All the collected material will be deposited in the archives. This paper provides a brief summary.

The expedition team (16 members including one post-doctoral fellow, one Ph.D. student and 14 undergraduates including two botanists – Anne and Laura - and 12 zoologists: Fig. 1) sailed from Scrabster in Scotland, via Kirkwall, Orkney and Lerwick, Shetland to Tórshavn, capital of the Faroe Islands on 17th July and stayed until 5th August (20 days). The team camped in the grounds of the Youth Hostel and were able to use its kitchen for catering and its toilets, shower and sauna. They did their own catering, supplemented by many samplings of the local pastries and coffees. The team even tried whale meat purchased locally which came as dark coal-like chunks of flesh along with pale potato-like lumps of blubber. No-one having any idea how to cook whale meat, the whole lot was stewed for hours in the youth hostel kitchen suffusing the entire hostel with a strong fishy smell. The hostel provided good interactions with other visiting groups from Newcastle and France. The expedition was funded by local Glasgow businesses, such as Tunnocks, as well as by the Carnegie Trust.

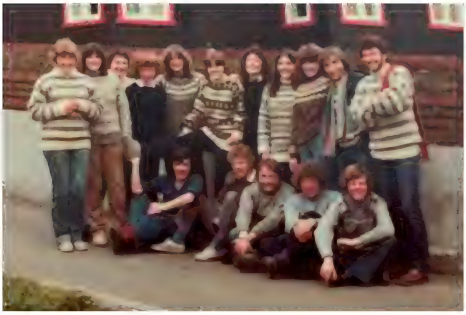

Fig. 1. The expedition team in front of Tórshavn youth hostel, Faroe Islands. Back row, left to right: Laura Vogt, Griselda Campbell, Anne Kominsky (?), Claire O'Brien, Margaret Muir, Kathryn Broadway, Lesley Orr, Clotilde Carlow, Susan Melrose, Tom Bladon, Malcolm Beveridge. Front row: Alister Hamilton, Peter Mayhew, Huw Smith, Matthew Service, Myles O'Reilly. (Photo: Clotilde Carlow)

The expedition worked on three main themes;
1. An investigation into hunting and killing methods of long-finned pilot whales (*Globicephala melas*), and an estimate of the numbers being killed.

It was also planned to collect whale teeth for age determination and examine whale stomachs for the presence of squid beaks to contribute to a study at Plymouth Marine Laboratory. However, no major pilot whale kill (known locally as a *grindadráp*) happened during the expedition, although landing and processing of fin whales (*Balaenoptera physalus*) did happen and was observed (Fig. 2). Some baleen plates from old whale skulls beached near the processing station were collected. The whale team, led by Malcolm Beveridge, carried out attitude surveys among the local people without experiencing any hostility, although the Scottish students were looked at suspiciously when observing whale processing. Faroese whaling was internationally notorious, and it was anticipated that the local people would be defensive and possibly unwilling to speak about it.

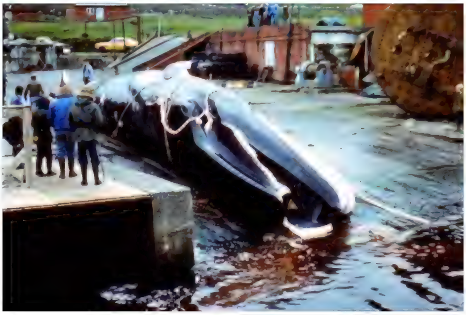

Fig. 2. Captured fin whale (*Balaenoptera physalus*) at the whaling station, Faroe Islands, ready to be processed. (Photo: Matthew Service)

2. A study on the prevalence of the parasitic nematode *Anisakis* spp. in Atlantic cod (*Gadus morhua*) processed at a commercial plant in Tórshavn.

The parasite can enter the human food chain through the eating of raw or under-cooked cod. The team, led by Dr Huw Smith, sampled from processed and unprocessed fish, searched local literature, visited hospitals and spoke to staff, who confirmed the occasional incidence of *Anisakis* infection in the human population. Huw was motivated to undertake this study by finding patients at Stobhill Hospital in Glasgow, with stomach problems related to eating infected fish. Huw Smith went on to a distinguished career in parasitology, founding and directing the Scottish Parasite Diagnostic Laboratory, before sadly dying at the early age of 63 (Innes *et al*., 2011). Team member Margaret Muir remembers horrifying her parents back home by finding worm cysts in fish purchased from the local fishmonger. Team member Clotilde Carlow was so inspired by the work that she proceeded to a career in human parasitology, via a Ph.D. at the London School of Hygiene and Tropical Medicine and then to New England Biolabs.

3. Observations on kleptoparasitism (food-stealing) by skuas.

The bird team, led by Myles O'Reilly and Peter Mayhew, visited several of the archipelago's 18 islands, but skuas were hard to spot, and the team resorted to making general records of seabird occurrence instead. Myles kept a daily record of species encountered, mainly birds but also mammals, plants and other taxa. Puffins were very abundant on some of the islands. Peter went on to a Glasgow Ph.D. and then a career in wildlife conservation with the RSPB.

Lesley Wiseman-Orr's diary gives a vivid account of the expedition's daily activities, describing the beauty of the islands, the occasional awfulness of the weather, local festivities and the surprising ease of getting around. The team hired a car for longer journeys, but it was often possible to hitch-hike, with local people very willing to go out of their way. However, in those pre-mobile phone days, arranging appointments to meet people was often very frustrating. The enthusiastic reaction of the reunion participants to the mention of the expedition, 40 years on, was testament to the impact of the expedition experience, as documented in detail by Harper *et al.* (2017). We hope that reports on some of the other "missing" expeditions (Czechoslovakia, 1975; Pyrenees, 1975; Crete, 1980; Morocco, 1973; South Uist, 1980) turn up eventually.

The expedition team belatedly thanks the Carnegie Trust for the Universities of Scotland, and other sponsors, for financial support. The authors thank Matthew Service and Clotilde Carlow for permission to include their photographs, and both Clotilde Carlow and Margaret Muir for personal recollections.

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Chrysoclista linneella (Clerck, 1759) (Lepidoptera: Parametriotidae): a moth new to Scotland

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During a visit to Callendar Park, Falkirk, Stirlingshire on 10th August 2019, in warm, sunny conditions, a small swarm of an unfamiliar and strikingly marked moth was seen by the first author near the trunk of a common lime tree (*Tilia* x *europea* L.) at NS897793. The swarm, close to the eastern side of the trunk at a height of around 2 m, is estimated to have comprised a few dozen individuals. An example that alighted on the trunk was captured and was later identified as *Chrysoclista linneella* (Clerck, 1759), a species whose current known distribution in the British Isles extends only as far north as Ulverston, Cumbria (Dr Mark Young, pers. comm.).

This "micromoth" species is a member of the family Parametriotidae, although over the years it has moved through several re-classifications during which it has been positioned in a number of other families. It is one of a group of species that differ from related moths in being bark feeders or twig borers rather than exploiting leaves. *C. linneella* utilises one of the native European lime trees of which the common lime is prevalent in Callendar Park. From this behaviour it has been allocated a descriptive English vernacular name of linden bark borer in North America, where it was introduced into New York at some time prior to 1928 (BugGuide, 2019). In Britain two common names have been suggested. One is Linnaeus's spangle-wing, an approximate translation of its biological name: *Chrysoclista* means gold-washed in Greek (Emmet, 1991); and the other is lime cosmet. Neither of these is as descriptively useful as the American version.

To follow up this interesting discovery a visit was made by the second author on 23rd August 2019 and more examples were seen on a lime tree trunk (Fig. 1). There was a strong breeze and no adult moths were flying, but mating pairs and individuals were sitting exposed to view on the leeward side of the trunk (Fig. 2). Of seven lime trees examined two others showed signs of larval feeding in the form of reddish-brown frass (Fig. 3), but no adults were seen. It is possible the mini-populations on these trees were yet to emerge from their pupae or had already done so and had mated and died or dispersed.

This Scottish record is a considerable extension of the known U.K. distribution of *C. linneella*. The National Moth Recording Scheme local recorder for Stirlingshire, Dr Martin Culshaw, has been informed of this occurrence and Drs Keith Bland and Mark Young confirmed it as new to Scotland.

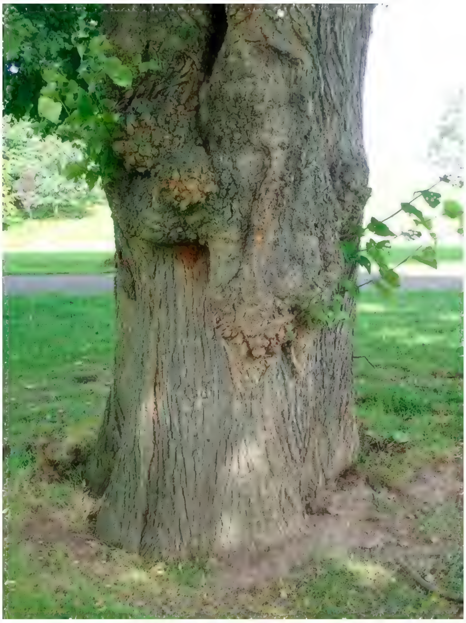

Fig. 1. Common lime (*Tilia* x *europea*) in Callendar Park, Falkirk, Scotland, 23rd August 2019, which was host to the moth *Chrysoclista linneella*. (Photo: E.G. Hancock)

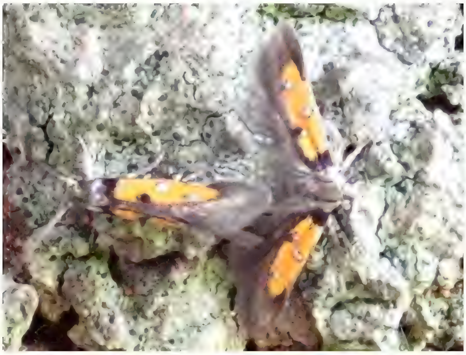

Fig. 2. A mating pair of *Chrysoclista linneella* on common lime (*Tilia* x *europea*) trunk, Callendar Park, Falkirk, 23rd August 2019. The wing length including apical fringe was 5.00 mm. (Photo: E.G. Hancock)

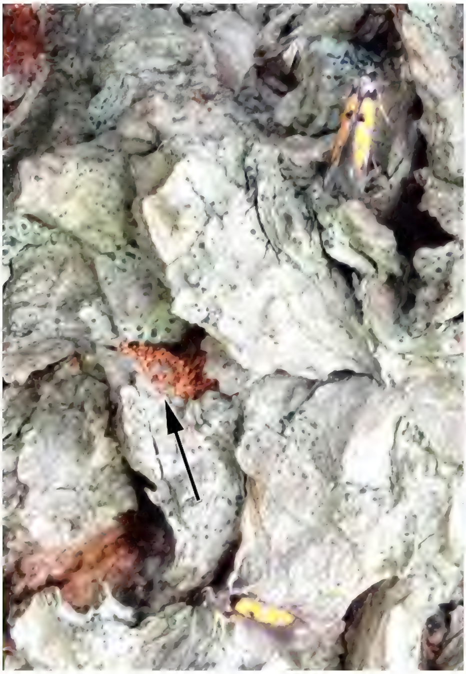

Fig. 3. Two adult *Chrysoclista linneella* with a patch of reddish-brown caterpillar droppings (frass) visible between two flakes of bark (arrow), Callendar Park, Falkirk, 23rd August 2019 (Photo: E.G. Hancock)

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The crystal jellyfish (*Aequorea vitrina*) in Loch Bracadale, Isle of Skye, Scotland

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Jellyfish are among the most conspicuous organisms in Scottish seas during the summer months and include several well known species such as the moon jellyfish (*Aurelia aurita*), the lion's mane jellyfish (*Cyanea capillata*), or the barrel jellyfish (*Rhizostoma octopus*) (Marine Conservation Society, 2019). Most large coastal jellyfish belong to the class Scyphozoa in which the free swimming sexual stage, the medusa, is very large and the overwintering polyp stage, the scyphostoma, is comparatively small and attaches to rocks, stone or shells on the seabed (Hayward & Ryland, 2017). The morphology and biology of all British Scyphozoa has been investigated in detail by Russell (1970a) and the same author also produced identification guides for all the Scyphozoa of the North Atlantic (Russell, 1976, 1978).

However, there are other jellyfish in British waters, which are from the class Hydrozoa. These are better known as hydroids, or sea firs, forming branching growths of polyps, which attach to rocks, stones, or seaweeds. There are over 100 species of hydroid found in British waters and many of these also produce a swimming medusa (Cornelius, 1995a,b; Schuchert, 2012; Hayward & Ryland, 2017). The known medusae of British hydroids have also been investigated and beautifully illustrated in a monograph by Russell (1953). Most of the British hydroid medusae are small with around half under 1 cm in size and the remainder rarely attaining 5 cm. However, there are a few larger species with diameters ranging from six to over 20 cm, i.e. comparable in size to the scyphozoan medusae.

In the summer of 2012, dozens of transparent jellyfish, up to around 15 cm diameter, were observed by PS at Colbost Point (NG308394) in Loch Bracadale, Isle of Skye, Scotland. The jellyfish were first spotted on 9th July swimming close to the shore (Fig. 1). They were still present in the area ten days later when a smaller individual (diameter around 7 cm) was captured and placed in a large beaker for close-up photography (Fig. 2). The jellyfish were mostly transparent with a circlet of whitish radial canals and long marginal tentacles. They were readily identifiable as crystal jellyfish of the genus *Aequorea*, being distinct from any of the more common scyphozoan jellyfish found inshore (Naylor, 2011).

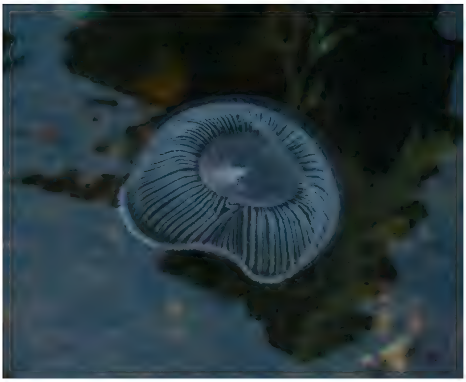

Fig. 1. Crystal jellyfish (*Aequorea vitrina*), around 15 cm diameter, swimming by water's edge at Colbost Point, Loch Bracadale, Isle of Skye, Scotland, 9th July 2012. (Photo: P. Semler)

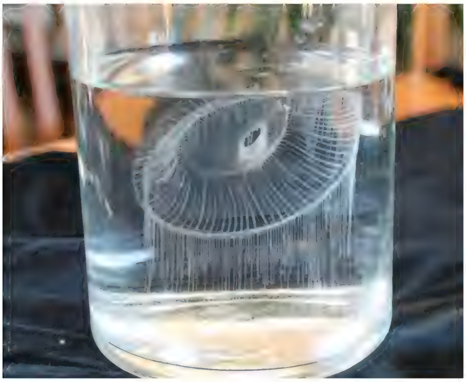

Fig. 2. Captured crystal jellyfish (*Aequorea vitrina*), diameter about 7 cm, from Colbost Point, Loch Bracadale, Isle of Skye, Scotland, 19th July 2012. (Photo: P. Semler)

Of the four *Aequorea* species known from British waters, *A. macrodactyla* and *A. pensilis* are recorded only from the south-west (drifting from waters further south). The other two, *A. vitrina* and *A. forskalea,* are described as common (Cornelius, 1995a), though both are referred to as sparse around mainland Scotland (Fraser, 1972). The captured specimen from Loch Bracadale had around 100 radial canals with approximately three marginal tentacles per radial canal, indicating it to be *A. vitrina* (Russell, 1953, 1970b; Cornelius, 1995a). The National Biodiversity Network Atlas (NBN, 2019) shows only six records for *A. vitrina* in Scottish waters, occurring in Orkney, Shetland, the island of North Rona and Loch Carron, Wester Ross, Highland. In contrast, there are 27 records for *A. forskalea*, mostly scattered around the north and north-west of Scotland with one find from Loch Eishort, Isle of Skye and a single east coast record from North

Queensferry in the Firth of Forth. Hence the occurrence of *A. vitrina* in Scottish waters seems to be relatively unusual. Observations by PS in the Loch Bracadale area since 2012 have, to date, produced no further sightings.

Only two other hydrozoan medusae from British coastal waters exceed 5 cm in diameter but are unlikely to be confused with *Aequorea* species. One of these, *Tima bairdii,* attains a diameter of 6.5 cm. It has only four radial canals, a distinct protruding mouth, and 16 marginal tentacles. It is frequent in the North Sea and may strand in large numbers on the east coast of Scotland and north-east of England. The other species, the white-cross jellyfish (*Staurophora mertensii*), is one of the largest hydrozoan medusae known and may reach over 20 cm in diameter. It may be mature from around 4.5 cm and has four radial canals (forming the white cross), a non-protruding mouth, and over 100 marginal tentacles. It is a vagrant from the north and has been recorded in Shetland and along the north-east coast of Britain as far south as Northumberland, and also off the west of Scotland in Clyde Sea Area.

The 2012 crystal jellyfish sighting from Skye is highlighted here as most hydrozoan jellyfish are likely to go unrecognised. They are missing from most sea shore guides, although *A. forskalea* is included in guides by Naylor (2011) and Trewhella & Hatcher (2016). Crystal jellyfish could be mistaken for juvenile moon jellyfish. Indeed a large swarm of puzzling jellyfish, observed in Liverpool harbour, England by MOR in October 2007, were initially thought to be moon jellyfish. They were transparent but lacked the four violet gonad rings characteristic of moon jellyfish and at around 10-15 cm diameter were rather small for moon jellyfish so late in the year. Unfortunately it was not possible to get close enough to these jellyfish to see any morphological details but it seems possible that these might have been an unusual occurrence of *Aequorea* crystal jellyfish.

Jellyfish blooms have become a potential problem for aquaculture and just a few weeks later in November 2007, swarms of the mauve stinger jellyfish (*Pelagia noctiluca*), an infrequently recorded scyphozoan jellyfish, caused mass mortalities of salmon at a marine cage fish farm at Glenarm Bay in Northern Ireland (BBC News, 2007). Around the same time, an invasion of mauve stingers and a smaller hydrozoan medusa, *Solmaris corona*, caused the death of numerous caged salmon in Skye (Nickell *et al.*, 2010). It seems then that in November 2007 an exceptional incursion of atypical pelagic jellyfish extended along the west coast of Scotland and into the Irish Sea, perhaps reaching as far as Liverpool.

It is hoped that highlighting some of these unusual jellyfish will encourage beachcombers and naturalists to look out for such interesting visitors to our shores. Rare or unusual species could appear almost anywhere and even species previously unknown in Scottish waters could turn up (see Govindarajan *et al.*, 2019). A similar jellyfish invasion caused the death of thousands of caged salmon in North Uist in the Outer Hebrides during November 2014 (BBC News, 2014).

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Dr Oliver Rackham, the ancient Mugdock Wood and the boundary pollard oak that never was

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Sadly on 12th February 2015 the noted botanist Oliver Rackham died suddenly and unexpectedly. I was privileged to have met him in the early 1960s when he and I were young researchers at the University of Cambridge, England. I had great admiration for his depth and breadth of knowledge which included an ability to read mediaeval Latin. Oliver could leave me overawed at times.

Oliver was the best known British exponent of the historical ecology of woodlands and became famous with the publication of his first two books in consecutive years: *Hayley Wood* and *Trees and Woodlands in the British Landscape* (Rackham, 1975, 1976). Although the latter especially is a great read and full of interest, there is something annoyingly wrong about the title. It should have referred to "*the English Landscape*" because there is so little in the first edition of the book about the other parts of the U.K. His book *The Ash Tree* (Rackham, 2014) is every bit as cogent, informative and readable as the first books and all the various others in between. Finally in 2019 there appeared a posthumous book on the woodlands of a part of Cornwall *The Ancient Woods of the Helford River* (Rackham, 2019).

In 1985 Oliver came to Scotland and stayed for a few days with my family in Milngavie, East Dunbartonshire. I showed him the oak woodlands (*Quercus petraea* and *Q. robur*) at Mugdock (East Dunbartonshire and Stirling), Garscadden (Glasgow) and Inchcailloch (Loch Lomond) and was glad to get his observations on all three places.

Oliver kept very many small identical notebooks of his woodland studies and other botanical topics. Painstakingly pencil-written in a clear hand, they are kept in the library of Corpus Christi College, University of Cambridge. There Oliver was an undergraduate, then a Fellow and eventually the Master (for a three year stint, the usual practice in that college). Very conveniently, the notebooks are now digitised and online and can be accessed at http://cudl.lib.cam.ac.uk/collections/rackham/1.

Oliver published about Mugdock Wood in his 2006 book and made the curious statement that few of the oaks had been coppiced. Certainly by comparison with the vast majority of the many alders (*Alnus glutinosa*) that have been coppiced, the oaks are much less so. However, on the southwest-facing steep slope just above the main track there are scores of coppiced oaks (Fig. 1).

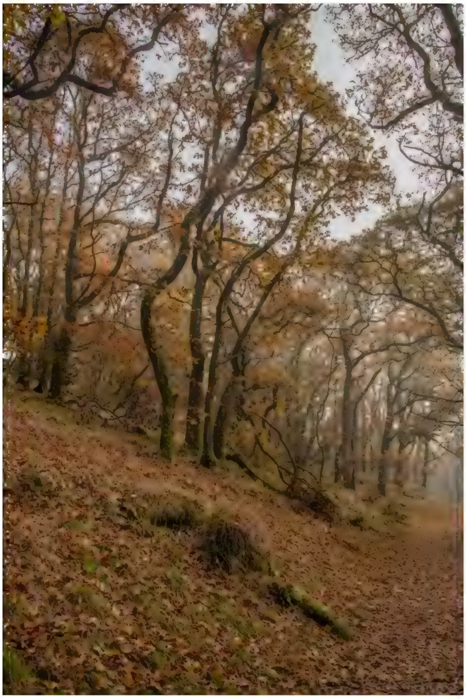

Fig. 1. View of Mugdock Wood, East Dunbartonshire, Scotland, from the main track (now part of the West Highland Way) looking southeast and showing some of the many multi-trunked oaks. (Photo: D.C. Palmar)

At the northwest end of the wood, close to the road known as the Khyber Pass, Oliver was impressed by a coppiced oak with a ring of several trunks so widespread that coppicing must have occurred repeatedly for perhaps 400 to 500 years according to him (Fig. 2). I was all ears. Trees are shown near Mugdock Castle in the Dunbartonshire map of the *Blaeu Atlas of Scotland* published in 1654. Indisputably it is an ancient wood. Documents first mention it in the 13th century. According to Oliver, Mugdock is a Welsh name (Maesiddwg). Therefore one has to suppose that it goes back to the Britons of Strathclyde who spoke an early form of Welsh.

In the wood on a steep slope very close to the Allander Water we came across an oak which Oliver declared could be a boundary pollard. I was even more all ears. It was the first such tree to be recognised in Scotland for all I knew. However, revealingly, there is no mention of that tree in Oliver's notes or in his 2006 book. So evidently he had doubts even before the first writing up.

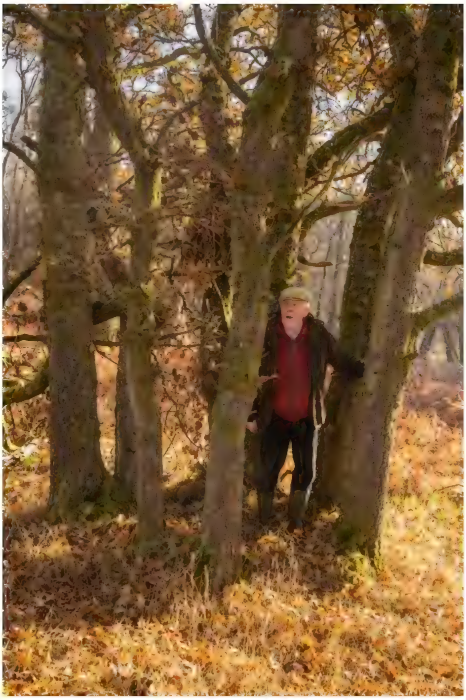

Fig. 2. The author at the anciently and repeatedly coppiced oak (*Quercus petraea* and *Q. robur*) at the western end of Mugdock Wood, East Dunbartonshire, Scotland. (Photo: D.C. Palmar)

However, the story does not end there. In the late 1980s under my supervision Mrs Jean Stevenson was a botany undergraduate and carried out a final year project on Mugdock Wood (Stevenson, 1990). I had shown Mrs Stevenson the boundary pollard of which she makes no mention in her paper. The reason was that she found that it was not a *pollard*, boundary or otherwise, but very surprisingly a *coppiced* oak. How can one mistake a pollard for a coppiced tree? The answer is: very steep topography, which had changed markedly with enough of the ground disappearing downslope leaving what looked like a trunk being in reality a massive, exposed root. Furthermore, a simple inspection at what had been the former soil level showed colour changes and even some tiny pebbles in the bark. I told Oliver about it but he did not reply, if I recall correctly.

Not having visited the tree in question for many years, I tried to find it twice in 2017 without success. It may well have disappeared long since downslope and into the Allander Water.

I am grateful to David Palmar for taking the photographs used in this article.

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A re-assessment and review of some published amphibian and reptile records in the Clyde area, Scotland

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A number of compilations of herptile (amphibian and reptile) records pertaining to the Clyde area, Scotland created by Dr J.A. Gibson were published in *The Western Naturalist* and *The Scottish Naturalist* during the 1980s and 1990s (e.g. Gibson, 1998; Gibson, 2003; and references cited therein). Dr Gibson edited and published both periodicals at the time. The herptile records that these publications contained were subsequently digitised for the Biological Records Centre (BRC) at Monkswood, Cambridgeshire, England and added to their database (H. Arnold, pers. comm.), whence they were submitted to the National

Biodiversity Network (NBN; https://nbn.org.uk/) when it was created. The BRC records were also made available to Glasgow Museums Biological Records Centre (GMBRC), where doubts arose about their reliability, particularly those derived from the 10 km distribution maps in some of the publications.

Because of these doubts a need to review the herptile records in the national databases was discussed repeatedly at meetings of the Council of the Glasgow Natural History Society (GNHS) and the Clyde Amphibian and Reptile Group (CARG). This culminated in a determination to re-assess the records. To do this an application was submitted to the Blodwen Lloyd Binns Bequest Fund of GNHS for funding to underwrite costs incurred during the review process, which was successful.

Independently, the records were explicitly excluded from *The Amphibians and Reptiles of Scotland* (McInerny & Minting, 2016), with the reasons for this described in the bibliography where two Gibson publications were listed.

The BRC data are now managed by the Centre for Ecology and Hydrology (CEH), Wallingford, Oxford, England. The Gibson sourced records have new reference numbers, and so a new copy of the data was obtained so that appropriate feedback, including the assessment of the individual records, could be provided to CEH at the conclusion of this review process.

Initially a list of Gibson publications was collated using the primary literature and other cited papers in the GNHS Library (Gibson, 1998; Gibson, 2003; and references cited therein). This allowed the interrogation of online resources such as the Biodiversity Heritage Library (https://www.biodiversitylibrary.org), and the National Library of Scotland to allow copies of publications to be sourced and reviewed. From these publications records were extracted and, where possible, the source of the records was noted. Source publications were accessed by the same means, for verification purposes.

The herptile records were considered and reviewed following a consistent and objective procedure:

1. Records were accepted and retained where a source could be independently verified.
2. Record sources that were not from a Gibson publication were accepted and retained, even if they could not be independently verified.
3. Records sourced directly from a Gibson publication were considered not verifiable if they lacked information to confirm validity. Such information included: a detailed grid reference, date of record, name of original recorder, number of specimens, or accompanying notes and photographs. Such records were rejected.

All records were then assessed against the NBN Gateway criteria for record validity and verification, prior to submission to the GMBRC for further verification and appropriate amendment of the same records in the GMBRC database. These amended records can be accessed by enquiries to the GMBRC (https://www.glasgowlife.org.uk/museums/biological-record-centre).

The unverified rejected records will be retained in the GMBRC database, though marked "considered incorrect" to prevent such records from being reproduced in future reports and publications. Importantly, this procedure also provides an "audit trail" for future reference, and is therefore preferable to deleting the records entirely. This information, along with this publication, will be forwarded to CEH so that they can treat the same records similarly and update the NBN Atlas appropriately.

This short note describes an approach to re-assess a number of herptile records in the Clyde area sourced from Gibson publications. A large number of these have been found to be un-verifiable and so have been removed from natural history databases. This results in databases of credible and verified herptile records for the Clyde area.

Comparable issues with similar sourced records are found in databases for other area of Scotland, for example Argyll (Lorne Natural History Group), where we suggest a related approach should be adopted and implemented.

Thanks are due to Henry Arnold (Monkswood) for the original records digitised by BRC; and to Stephanie Rorke (Wallingford), CEH Database Manager, for the CEH copy of the data, and for implementing our recommendations. We are grateful to the Administrators of the Blodwen Lloyd Binns Bequest Fund for a grant to support the review process.

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Annual abundance of chanterelle mushrooms (*Cantharellus cibarius*) in Scotland

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The chanterelle fungus (*Cantharellus cibarius*) is widespread throughout Scotland and is found in woodland habitats where it can be common (Jordon, 2004; Phillips 2006; NBN Atlas, 2019). Being edible and considered to have gastronomic qualities, the mushroom fruiting body (Fig. 1) is collected and sometimes sold commercially. Publications describing fungi state that the mushrooms are present above ground from summer through to late autumn, although the exact period is not stated.

I have been collecting chanterelles at a site near Loch Lomond each year since 2011 in a small mixed woodland of birch *Betula* spp., oak *Quercus* spp., rowan *Sorbus* spp. and holly *Ilex* spp., of about 10 hectares in size (Fig. 2). On each foray I have recorded the mass of wet mushrooms harvested. The results of these forays are shown in Fig. 3. Over the nine year period about 250 kg of mushrooms were harvested in total. Mushrooms first appeared in June in very small numbers just in two years (2015 and 2019) after rain, but it was not until July that significant quantities were found. Highest numbers were present in August and September, with a decline through October, and the last in early November.

Harvesting the mushrooms did not appear to have reduced their presence in the wood, with instead increased numbers harvested year on year (Fig. 3). Indeed, the woodland contains fungi of a wide range of other species, which were also present every year, many in high numbers.

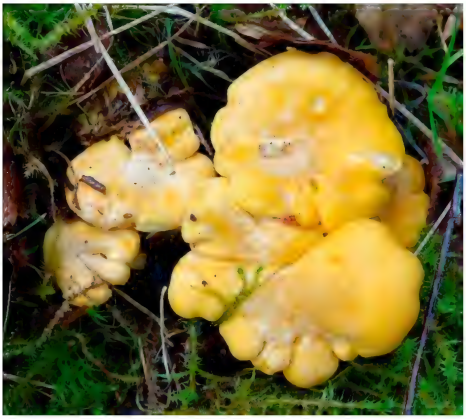

Fig. 1. Chanterelle mushrooms (*Cantharellus cibarius*), Loch Lomond, Scotland, July 2014. (Photo: C.J. McInerny)

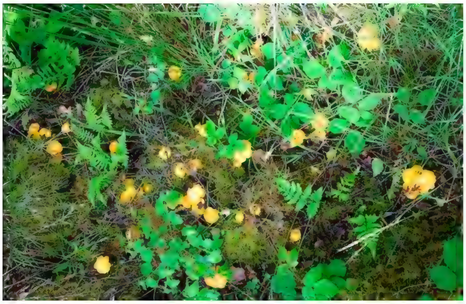

Fig. 2. Chanterelle mushrooms (*Cantharellus cibarius*), Loch Lomond, Scotland, September 2016. (Photo: C.J. McInerny)

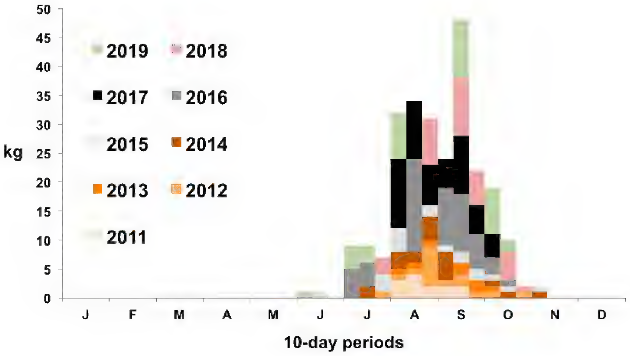

Fig. 3. Annual harvest of chanterelle mushrooms (*Cantharellus cibarius*) in kg by month, Loch Lomond, Scotland, 2011-2019.

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Evidence for breeding lime hawkmoth (*Mimas tiliae*) in Glasgow, Scotland

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The lime hawkmoth (*Mimas tiliae*) is an attractive olive and sand-coloured, medium-sized hawkmoth with a wide distribution in Europe, the Middle East and Asia (Pittaway, 1993). There are two 19th century records of the moth in the Glasgow area: one by John Dunsmore near Houston, Renfrewshire; the other by Robert Dunlop near Kilmarnock, East Ayrshire. Neither is dated, but Dunsmore was active from *ca.* 1850. These records are cited by Dalglish & Ord (1901) as *Dilina tiliae* and later by Stewart (1915) as *Smerinthus tiliae*. The moth is said to be currently absent from Ireland, Scotland, northern Scandinavia and Arctic Russia (Pittaway, 1993), but there is a general assumption that it is moving northwards in the U.K. (UKMoths, 2020). South (1939) stated that it could be found no further north in England than Yorkshire, and later Hill *et al.* (2010) showed a line from Morecombe Bay to Newcastle as the northern limit. Currently, the NBN Atlas gives the English-Scottish border as its northern limit aside from an "unconfirmed" report on the south Ayrshire coast (NBN, 2020). There was considerable surprise, therefore, when a mating pair of lime hawkmoths was photographed in Glebe Street, Renfrew, Renfrewshire on 27th May 2016. Whilst publicised at the time on the Paisley Natural History Society website (PNHS, 2020) and in the local press (*Paisley Daily Express*, 20th June 2016), there were no subsequent sightings. Indeed, the possibility was raised that the pair could have been purchased via one of several commercial operators dealing in hawkmoths.

On the late afternoon of 12th August 2019 I found a large green hawkmoth caterpillar on top of a low wall in Orleans Avenue, Jordanhill, Glasgow (Fig. 1). Close examination revealed a blue horn on the tail with a pink blush on the undersurface of the base. The tail also bore prominent yellow warts surrounding a dark red patch. The spiracles were ringed in red and there were seven oblique yellow stripes on the light green body. This was subsequently confirmed as a final instar lime hawkmoth larva.

The caterpillar was found immediately underneath a mature lime tree. I counted 28 such trees in Orleans Avenue, with very substantial numbers (over 100) in that section of Victoria Park which is immediately opposite. It is impossible to say whether the species originally arrived in Glasgow by natural northerly spread or by some artificial means, but the fact that a fully-grown larva can be encountered in these circumstances and close to its natural food-plant is strongly suggestive of successful colonisation. Future light trapping for moths in that area would be of interest.

I am grateful to Richard Weddle and Glasgow Museums Biological Record Centre for assistance with literature, and to Roy Leverton for verifying the identification.

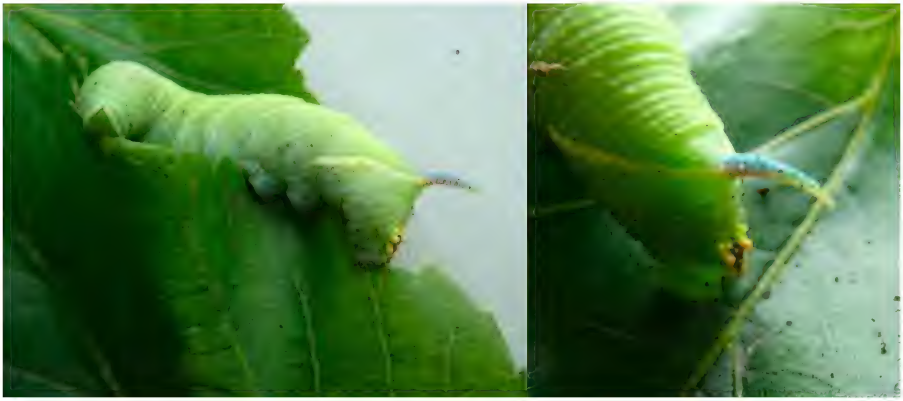

Fig. 1. Lime hawkmoth (*Mimas tiliae*) larva, Jordanhill, Glasgow, Scotland, 12th August 2019. The caterpillar (left) was 60-65 mm long. Its tail (right) had a blue horn with a pink blush on the undersurface of the base. (Photos: A.P. Payne)

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A shark louse from a porbeagle shark stranded near Arbroath, Scotland

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The Scottish Marine Animal Stranding Scheme (SMASS) is responsible for examining stranded whales, dolphins, seals, marine turtles and basking sharks on Scotland's shores (SMASS, 2016). Post mortem investigations are carried out on a number of the stranded animals to establish a cause of death and to monitor and report on the species in Scottish waters.

On 4th August 2019 a porbeagle shark (*Lamna nasus*) was found washed ashore near Arbroath, Angus, Scotland (NO6390840173) (Fig. 1). The specimen, a 214 cm male weighing 70 kg, was reported to SMASS. This species is currently not part of SMASS's remit, and instead the stranding was attended by curators of the National Museum of Scotland. During the examination a single shark louse (a parasitic copepod) found attached to the shark was removed for deposition in the museum (Reg. NMSZ 2019.70). Necropsy samples were also taken and the carcass was returned to the museum and frozen for further study.

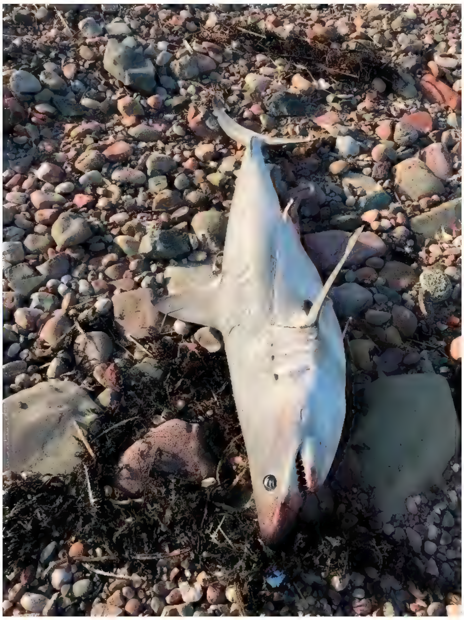

Fig. 1. Stranded porbeagle shark (*Lamna nasus*), 214 cm in length, on the shore near Arbroath, Angus, Scotland. (Photo: G. Hantke)

Parasitic copepods are well known as external parasites on fishes in British seas with nearly 130 species known from British waters (Kabata, 1979, 1992). Perhaps the most widely known species are the sea louse (*Caligus elongatus*) and salmon louse (*Lepeophtheirus salmonis*), both serious pests of farmed salmon (*Salmo* spp.), and the gill maggot (*Lernaeocera branchialis*), which attaches to the gills of over a dozen fish species. Different copepod species have different host affinities but some utilise a wide variety of hosts. The common sea louse (*C. elongatus*) has been found on over 100 fish species and has also been found on whales (O'Reilly, 1998; Ólafsdóttir & Shinn, 2013). However, there is a problem with many *C. elongatus* host records since molecular data suggest it comprises two cryptic species (Øines & Heuch, 2005).

Six different parasitic copepod species are recorded from porbeagles in British waters. Two of these - *Nemesis robusta* and *Phyllothyreus cornutus* - attach only to the gill filaments. One - *Anthosoma crassum* - lives half embedded in the skin of its host with only the posterior protruding. Another species - *Ommatokoita elongata* - always attaches to the eye of its host, which is usually the Greenland shark (*Somniosus microcephalus*), and has only very rarely been found on porbeagles. The remaining two species - *Dinemoura producta* and *Echthrogaleus coleoptratus* - attach to the body or fins of their host, particularly to the trailing edge of the fins. They are both in the family Pandaridae with the adult females in the size range 10-18 mm. *D. producta* is up to 18 mm in length with an elongate two-segmented abdomen; *E. coleoptratus* is up to 14 mm in length with a shorter one-segmented abdomen.

The copepod collected from the porbeagle shark was 18 mm long (Fig. 2) and was found attached laterally, about 40 cm anterior to the tail fluke. It has a rounded shield-like cephalothorax with a pair of medial eyes and an elongated posterior trunk. Although slightly damaged, its trunk structure indicated it to be an adult female *D. producta*.

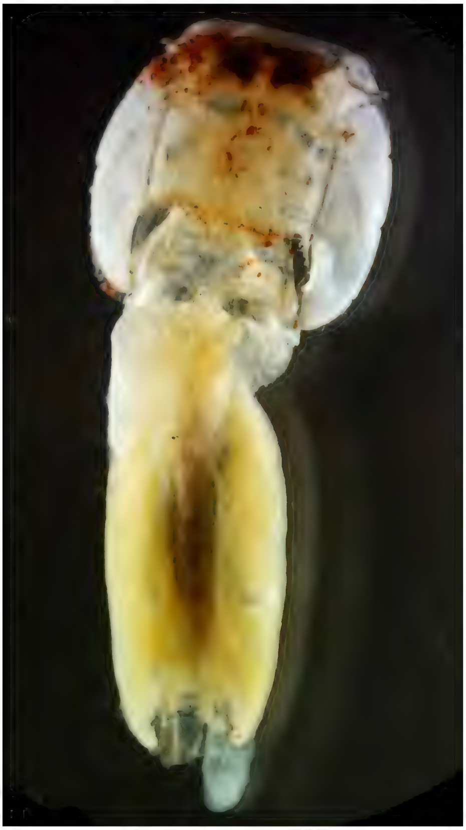

Fig. 2. Dorsal view of female shark louse (*Dinemoura producta*), 18 mm in length, from the stranded porbeagle shark (*Lamna nasus*). (Photo: R. Eustace)

Scott & Scott (1913) describe *D. producta* as a common finding from porbeagles with Scottish records from Shetland, Moray Firth, Aberdeen (fish market), south to Berwick-upon-Tweed Bay off the Scottish Borders, and an English record from Cornwall. They also cite a record from a thresher shark (*Alopias vulpinus*) in the Firth of Tay. The Plymouth Marine Fauna cites its occurrence on basking sharks (*Cetorhinus maximus*) (Marine Biological Association, 1957). Kabata (1992) refers to it as common in all sea areas of Britain, indicating its hosts in British waters include the spurdog (*Squalus acanthias*) and also the thresher, blue (*Prionace glauca*), porbeagle, shortfin mako (*Isurus oxyrinchus*), and basking sharks. *D. producta* is well known to occur on basking sharks off the coast of Scotland (Matthews & Parker, 1951) and Ireland (Scott, 1963). Adult female copepods carry a pair of egg sacs which are usually white when laid but become darker as they near hatching. Ovigerous female *D. producta*, bearing white eggs strings several centimetres long, may be quite conspicuous on basking sharks in U.K. waters and can sometimes be seen on video clips of slow swimming basking sharks on television documentaries or posted on the internet. An encounter with a basking shark off the Isle of Man, filmed with a pole-mounted camera by a kayaker (Rathore, 2018), shows numerous ovigerous copepods attached to the trailing edge of the large dorsal fin and the pelvic fins and also on the upper body between the dorsal fin and the tail fluke.

Stranded sharks are relatively unusual, although even an occasional basking shark has been found on beaches (BBC, 2016). The accurate identification of ectoparasites on British sharks requires careful examination. Given that observations are relatively scarce and hosts are difficult to sample, sourcing specimens for study relies on the sampling of sharks stranded on the shore or accidentally by-caught in fisheries.

The authors wish to thank Mariel ten Doeschate (SMASS) for informing us about the stranding and for helpful comments on this note, Fiona Ware (National Museums Scotland) for making the shark louse available for examination, and Ryan Eustace (SEPA) for provision of the copepod photo.

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Some significant botanical records from Loch Awe, Argyllshire, Scotland in 2019

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2019 was the final year of fieldwork for the Botanical Society of the British Isles (BSBI) Atlas 2020 project, which aims to map the distribution of vascular plant species across Great Britain and Ireland. As part of an RSPB sabbatical funded by RSPB Scotland and the Blodwen Lloyd Binns Bequest Fund, I spent eleven days recording in Argyllshire, Scotland during the year to contribute to the Atlas 2020 project. A total of 1,771 botanical records was collected and this Short Note describes some of the most interesting plant species encountered in the Loch Awe area, particularly those that are significant in the Argyllshire or U.K. context.

On 31st May, whilst recording on the south side of Loch Awe off the B840 near the western edge of Eredine Forest at NM91630518, Sarah Sanders and I found a population of Mackay's horsetail *Equisetum* × *trachydon*. This taxon is the hybrid between rough horsetail *Equisetum hyemale* and variegated horsetail *E. variegatum*. It was growing on the loch edge in a typically lowland situation at 40 m above sea level. This taxon has fewer than ten mapped occurrences this century in Scotland (BSBI, 2020) and is described as nationally rare, i.e. found in not more than 15 different hectads (10 km × 10 km squares) in the U.K. since 1987 (Stace, 2019). This occurrence is the first record in the BSBI database for Argyllshire (BSBI, 2020).

Published descriptions of its ecology elsewhere in the U.K. describe highly calcicolous habitats such as dune slacks, river banks and flushes in open damp vegetation with low competition from other plant species (Page, 1982). The habitat at Loch Awe is similar in the open and damp conditions, but did not appear particularly calcareous. Calcicolous herbs such as globeflower *Trollius europaeus* and northern bedstraw *Galium boreale* were growing nearby on dry rocks on the bank, but the wet shingle where Mackay's horsetail grew occurred in the drawdown zone of Loch Awe itself. Measurements recorded in Scottish Natural Heritage's Standing Waters Database record a pH of 5.83 in the north and 7.13 in the south of the loch, indicating that the loch varied from slightly acid to slightly alkaline (Lassiere *et al.*, 1993). The shingle substrate could have been calcareous, given the base rich rocks nearby on dry land, but no other plant species were growing in association with the horsetail to confirm this.

None of the hybrid parents were seen nearby, but this is typical for this taxon, which is capable of dispersing long distances as viable stem fragments (Page, 1982). There are records of variegated horsetail from nearby at the south western end of Loch Awe, on the loch shore by B.H. Thompson from 1988 and 1992 (BSBI, 2020). It would be worth checking these localities again, as Mackay's horsetail would appear more likely in this habitat than variegated horsetail, and the two can be easily confused. The nearest records of rough horsetail are about 50 km away. Mackay's horsetail appears to be a relict here, persisting vegetatively around the loch edge in the absence of at least one and probably both parents. Its vegetative fragments are likely to be distributed around the loch by wave action and draw down, which also create the open, low competition environment it needs to persist.

The most notable aquatic plant I recorded during field work in Argyllshire in 2019 was the introduced neophyte Nuttall's waterweed *Elodea nuttallii*, which I collected with a grapnel from the bank of Loch Awe by Kilchurn Castle (NN133276) on 3rd June. It was sampled along with Canadian waterweed *E. canadensis*, shoreweed *Litorella uniflora* and a quillwort, possibly spring quillwort *Isoetes echinospora*, but inconclusive as ripe spores were not available. This is one of only several records of Nuttall's waterweed from Argyllshire and the first record from Loch Awe. This North American species was first recorded from the wild in the U.K. in 1966 (Stace, 2019) and has since spread rapidly throughout lowland England north to the Scottish Central Belt. Elsewhere in Scotland it has a rather patchy distribution, stretching northwards to the Moray coast on the east. On the west side of the mainland, its current range extends to just north of Fort William, Highland (BSBI, 2020).

On 2nd June whilst descending the forest track by Kilmaha (NM942084) I noticed a mature bush of Californian honeysuckle *Lonicera involucrata* growing with native, self-sown scrub of the same age. It was a few hundred metres distant from the house and was not growing in a place where it is likely to have been planted. It was on the edge of the forest track and will likely be removed to keep the track open once it reaches a certain size. This is the first time this introduced species has been recorded from the wild in Argyllshire. It has a very scattered U.K. distribution, with the current nearest record being from Dunbartonshire, about 40 km to the south east. There are currently about 25 recorded hectad occurrences in Scotland (BSBI, 2020).

I would like to thank RSPB Scotland for supporting my sabbatical in 2019, including work in Argyllshire. I would also like to thank the Blodwen Lloyd Binns Bequest Fund and Glasgow Natural History Society for assisting with expenses for field work in Argyllshire and Dunbartonshire. I would like to thank Sarah Sanders for accompanying me on some of the above field work and Dr Fred Rumsey at the Natural History Museum, London for determining Mackay's horsetail from collected material.

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How not to be the perfect host: a simple tactic for avoiding sheep ticks (*Ixodes ricinus*)

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Ticks (Arachnida: Ixodida) are external parasites that require a blood meal at various stages of their life-cycle. The sheep tick (*Ixodes ricinus*) has been described as "one of the most dangerous animals in Europe" because whilst feeding it can transmit a range of pathogens that cause human diseases such as Lyme borreliosis (Lyme disease) and tick-borne encephalitis (Rahlenbeck *et al.*, 2016). Scotland has the highest incidence of Lyme disease in the U.K. (27% of all U.K. cases in 2001-2012: Cairns *et al.*, 2019) and this is predicted to increase as a result of changing climatic conditions (Li *et al.*, 2016). This note describes a simple method for reducing the risk of becoming a tick host and provides preliminary information on its effectiveness.

Sheep ticks employ a host-seeking strategy known as "vantage point host-ambushing": when environmental conditions are suitable they leave the ground micro-habitat of leaf litter and climb up available vegetation such as rush or grass stems (Carr & Salgado, 2019). They then stop, cling to the vegetation using their second to fourth pairs of legs, and adopt one of two postures: in the *questing posture* the first two legs are extended to the front, either immobile or waving actively (Fig. 1); in the *reposing posture* the forelegs are folded (Lees, 1948). Tick forelegs are important both for sensing an approaching host, which depends mainly on the detection of chemical and thermal stimuli by the Haller's organs located on these legs (Carr & Salgado, 2019), and for attaching to the host by means of their terminal claws (Voigt & Gorb, 2017).

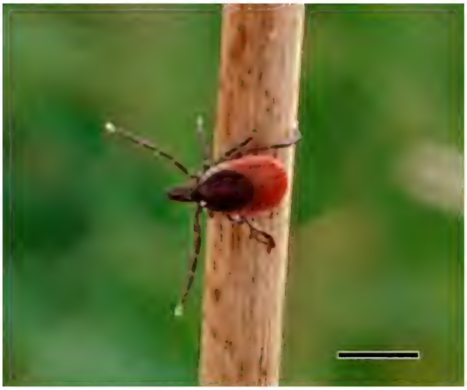

Fig. 1. A sheep tick (*Ixodes ricinus*) on a withered rush stem (*Juncus* sp.). The tick is demonstrating the questing posture. Photographed in Strachur Estate, Argyll, Scotland on 2nd May 2019. Scale bar = 2 mm. (Photo: I.C. Wilkie)

The following observations were made between 21st April and 28th May 2019 in Strachur Estate, Cowal, Argyll, Scotland in rough grassland dominated by the tussock-forming purple moor-grass (*Molinia caerulea*) (Fig. 2). When walking over such grassland it was noticed that sweeping the vegetation ahead with a stout wooden stick (normally used as a walking aid) tended to cause perching ticks to drop to the ground, thereby interrupting their host-seeking behaviour. The effectiveness of this method was then assessed by recording the effect on ticks of semi-standardised mechanical disturbance using the stick. Thirty ticks including adults and nymphs (immature stages) were observed. All were located near the tips of withered

M. caerulea seed-heads that were leaning towards or over established routes used by foxes (*Vulpes vulpes*), roe deer (*Capreolus capreolus*), and red deer (*Cervus elaphus*), as deduced from the presence of their respective droppings and/or tracks.

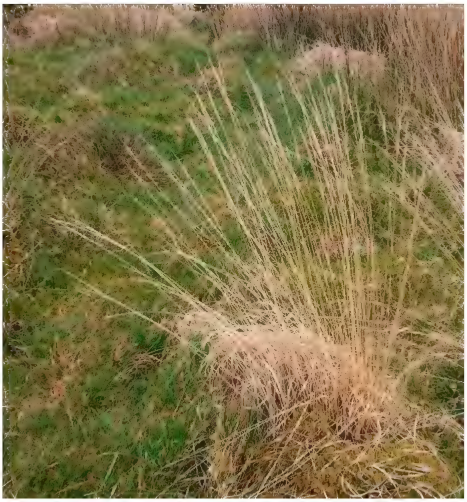

Fig. 2. Withered purple moor-grass (*Molinia caerulea*) at a location where the observations were made. Photographed in Strachur Estate, Argyll, Scotland on 21st April 2019. (Photo: I.C. Wilkie)

Ticks are more easily seen in April and May because the previous year's grasses are maximally bleached and there is little new growth. When a tick was spotted, the height of its vantage point was measured and then the grass stem was hit repeatedly with the stick (length 80 cm; diameter *ca.* 2.5 cm) roughly halfway between the vantage point and the ground and at a frequency of one hit per second; only light force was used - enough to deflect the grass stem without damaging it. The number of hits applied before the tick dropped was recorded.

The height of the tick vantage points was 42-160 cm (mean 78 cm). Fig. 3 shows that 25 ticks (83%) dropped after one to three hits; three ticks (10%) dropped after more than three (up to nine) hits; and two ticks (7%) could not be dislodged at all, even when the seed-head was nipped off and "flicked" repeatedly with an index finger. Since 83% of ticks dropped after their vantage point vegetation was hit one to three times, these results suggest that beating the vegetation ahead lightly with a stick or walking pole around once per second could reduce significantly the risk of being ambushed by ticks. A full-scale experimental investigation would be needed to confirm this and determine if such a tactic should be added to the list of safety measures already recommended to the public for avoiding ticks (see e.g. NHS, 2019).

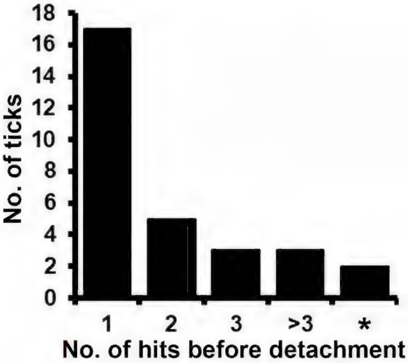

Fig. 3. Effect on 30 sheep ticks of semi-standardised mechanical disturbance. *No detachment.

The biological significance of these observations is not clear. A key question is: does the impact of the stick simply knock a tick off its perch because its grip is not tight enough (i.e. no behavioural reaction is involved), or does the tick react to the impact by releasing its grip? The latter would be an example of a dropping response. Many animals exhibit dropping responses whereby they fall suddenly under the influence of gravity alone, usually as a defensive strategy for avoiding predation (Humphreys & Ruxton, 2019; Wilkie, 2019). Although there appear to be no reports in the literature that external stimuli such as mechanical disturbance invoke a dropping response in sheep ticks, it is well known that they release their grip and drop from their host when they have completed their blood meal, and Lees (1948) noted that in laboratory conditions a questing tick that attaches itself to "neutral" objects like cotton wool "soon loses interest and drops off". It seems likely that the effect of mechanical disturbance on ticks described in this note involved a dropping response in at least some cases. Of the 28 ticks that dropped, 11 (39%) did so after more than one hit and therefore their grip was initially tight enough to resist dislodgement. Since the force applied at each hit was roughly the same, this implies that after one or more hits, a behavioural reaction - grip loosening - was instigated. Such a dropping response could be primarily defensive, for example enabling ticks to avoid incidental ingestion by larger grazing herbivores (Gish *et al.*, 2011), or perhaps more likely it could be a strategy for bringing ticks into contact with medium-sized mammals such as foxes passing below the level of their vantage points.

I am grateful to Keith Watson for grass identification and to a reviewer for helpful comments.

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A brief consideration of the later prehistoric appearance and possible significance of the great auk (*Pinguinus impennis*) in the Covesea Caves of north-east Scotland

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The Covesea Caves are located in north-east Scotland, on the southern coast of the Moray Firth. They comprise several individual sites that were used at various times from the Early Neolithic to the Roman Iron Age for mortuary activity (Armit & Büster, 2020; Büster, 2015): they include Covesea Caves 1 and 2 (disturbed by amateur excavations during the 1960s); and the Laird's Stables, which are the subject of current excavations by a team from the universities of York and Bradford (Büster & Armit, 2016, 2019); and the Sculptor's Cave, which was originally excavated in the 1920s and 1930s (Benton, 1931), revisited in the 1970s (Shepherd & Shepherd, 1979) and finally published as part of the Sculptor's Cave Project (Armit & Büster, 2020).

In total, 8,262 individual faunal bones have been identified and analysed for the Covesea Caves Project (from the Sculptor's Cave; Caves 1 and 2; and the Laird's Stables). 25% of this total has been identified as avian, with 488 bones (6%) belonging to species of seabird.

Within these seabird assemblages, a total of 30 individual bones have been identified as great auk (*Pinguinus impennis*), a now-extinct, flightless bird once found throughout the North Atlantic. The inability to fly rendered the great auk easy prey, and it was often hunted for its meat and fat (Svanberg, 2014). Overexploitation of the great auk was not due to subsistence alone, however. As populations dwindled, natural history collectors and museums eagerly hunted these seabirds for display of their eggs and skin (Minteer *et al.*, 2014).

The great auk originally inhabited regions across the North Atlantic, although remains have been found as far south as Florida and Bermuda. It was particularly widespread throughout the Scottish islands and coastal areas, with the remote islands used mainly for breeding. As such, many excavations in areas such as the Orkney Islands and Shetland have recovered numbers of great auk bones (Forrester *et al.*, 2007).

This Short Note describes the distribution and composition of the great auk assemblage found within the Covesea Caves, and discusses its significance.

Species identification was undertaken following the general methods and guidelines used by the zooarchaeological database of the North Atlantic Biocultural Organisation (McGovern *et al.*, 2008). For comparison of most osteological specimens, the archaeofaunal reference collection at the University of Bradford was consulted. In addition, the avian anatomical collection at the Natural History Museum, Tring, England, and Cohen & Serjeantson (1986) were used to confirm the identity of avian species.

Remains of the great auk have been identified in three of the four caves investigated. However, only one individual specimen was found at both Covesea Cave 1 and the Sculptor's Cave, with the overwhelming majority deriving from Covesea Cave 2. Preservation of the remains overall was consistently excellent, with little to no weathering or fragmentation. One recovered specimen represented the remains of an articulated "leg", including tibiotarsus, femur, fibula, and tarsometatarsus (Fig. 1). In addition, some bones still had the remains of soft tissue adhering to them (Fig. 2). Unfortunately, most of the great auk fragments derived from unstratified or mixed deposits (Table 1) but in Covesea Cave 2 five fragments were attributed to stratified contexts of Neolithic/Bronze Age (N = 2) or Medieval/Post-Medieval date (N = 3).

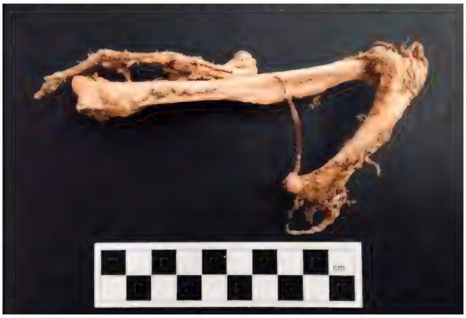

Fig. 1. An articulated great auk (*Pinguinus impennis*) leg fragment recovered at the Covesea Caves, north-east Scotland. Left to right: tarsometatarsus, fibula, tibiotarsus, and femur (Trench 4, Context 406, Covesea Cave 2). (Photo: A. Fitzpatrick)

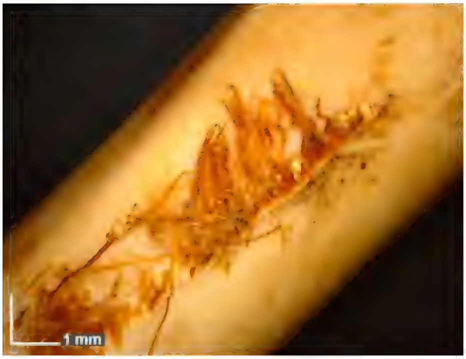

Fig. 2. Detail view of soft tissue remains on great auk (*Pinguinus impennis*) femur recovered at the Covesea Caves, north-east Scotland (unstratified context, Covesea Cave 2). (Photo: A. Fitzpatrick)

All of the great auk remains could be identified to skeletal element, with limb bones (74%), particularly humeri, dominating the assemblage (Fig. 3); there were no crania. None of the bones displayed evidence of butchery.

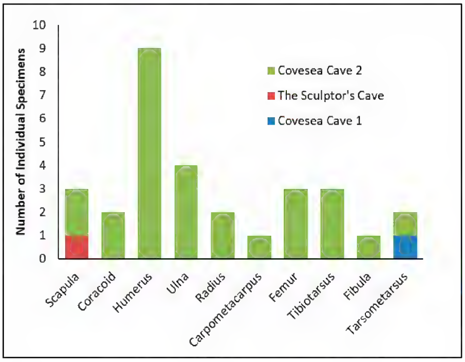

Fig. 3. Great auk (*Pinguinus impennis*) assemblage by skeletal element recovered at the Covesea Caves, north-east Scotland.

Site	Phase	Number of Individual Specimens
Covesea Cave 1	Unstratified/Mixed	1
Covesea Cave 2	Neolithic/Bronze Age	2
	Medieval/Post-Medieval	3
	Unstratified/Mixed	23
The Sculptor's Cave	Unstratified/Mixed	1
Total		**30**

Table 1. Location and dates of the Covesea Caves, north-east Scotland great auk (*Pinguinus impennis*) assemblage.

Clearly, there is precedent for considering the great auk as a possible subsistence food resource, which seems to have been the case until its extinction in 1844 (Serjeantson, 2001). Evidence for the consumption of great auk in prehistory exists across the British Isles, with many sites indicating a decline during the Late Iron Age, perhaps already as the result of overexploitation (Forrester *et al.*, 2007, Best & Mulville, 2013).

At least three of the caves (the Sculptor's Cave, Cave 1 and Cave 2) appear to have been used for mortuary activity at various times between the Early Neolithic and the Roman Iron Age. Faunal remains must be considered as potentially associated with funerary rites or related ritual activities which may have occurred concurrently with the deposition of human bones. Of course, subsistence and ritual are not mutually exclusive, as is evident from ritual feasting and consumption being a common practice in both the archaeological and ethnographic records (Fitzpatrick, 2007; Hayden, 2014; Madgwick & Mulville, 2015).

It is possible that the great auk was utilised in ritualistic activity apart from consumption. At Broxmouth hillfort in East Lothian, for example (a site which has produced the largest surviving faunal assemblage in mainland Scotland), cranial elements of a great auk were found adjacent to a near-complete horse skull, within an apparently structured deposit of 182 animal bones in a pit outside the south-west entrance to the Phase 3b hillfort (Armit & McKenzie 2013; Salvagno, 2013).

Perhaps the most striking ritual deposition of this type from the Scottish Iron Age is the placement of the complete head of a great auk (represented by its cranium and beak) behind the wall of Wheelhouse 2 at Cnip during its construction; a group of seven other great auk bones (probably from a single specimen) were also recovered from a single floor deposit in Structure 4 at the same site (Armit, 2006). The former example, which was one of a series of unusual deposits behind the wheelhouse wall, is interpreted as a foundation deposit associated with construction of the building.

It remains possible, of course, that, rather than reflecting either subsistence or ritual activity, the great auk remains from the Covesea Caves represent natural deposition. After all, the Covesea Caves are located on the coast of north-east Scotland, which would be a likely habitat for the species. The lack of butchery marks, as well as the absence of cranial elements, could also suggest this.

We would like to thank Dr Jerry Herman (Vertebrates Collection) and Dr Matthew Knight (Early Prehistory Collection) for supervising comparative analysis at the Collections Centre of the National Museum of Scotland in Edinburgh. The work described herein has been supervised by Dr. Julie Bond and Dr. Jo Buckberry at the University of Bradford, and Dr. Lindsey Büster and Professor Ian Armit at the University of York. It forms part of the Covesea Caves Project (www.coveseacavesproject.wordpress.com). Funding for this research was provided by the Glasgow Natural History Society Professor Blodwen Lloyd Binns Bequest, the Prehistoric Society, and the Society of Antiquaries of Scotland. Prior collection of samples took place during the Covesea Caves Project 2018 excavation season, with help from Danny Shaw, Rachael Kershaw, Rob Harman, Mike Offley, and Kevin Rutherford, and was funded by Historic Environment Scotland and Aberdeenshire Council.

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New records of sessile earthstars (*Geastrum fimbriatum*) and collared earthstars (*Geastrum triplex*) from the Glasgow area, Scotland

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Earthstars are one of our more recognisable types of fungi due to the distinctive star-shaped structure of their fruiting body. They are gasteromycete fungi, a type of puffball, enclosed in a pericarp which splits and unfolds to form the characteristic star shape. They tend to grow in dry places: under bushes, on dunes, in litter in dry conifer woodland, dry grassland, and often in manmade habitats such as unused railway lines. Many are found under yew (*Taxus* spp.) in churchyards. The release of spores is caused by raindrops or disturbance tapping the spore sac (Watling, 1973; Pegler *et al.*, 1995; Petersen & Læssøe, 2019).

Their apparent arrival and spread throughout the Glasgow area, Scotland, has been highlighted recently by McInerny (2019), who noted they were first recorded in 2004 and, according to the Glasgow Museums Recording Centre (GMRC), are now known from over 16 locations. These include Victoria Park, Kelvingrove Park, Kelvinbridge, Botanic Gardens, Bell Street, Springburn Park, Richmond Park, Bellahouston Park, Pollok Park, King's Park and Muirend. Many of the finds have been by members of the Clyde and Argyll Fungus Group (CAFG) who have undertaken numerous fungal surveys in and around the Glasgow area since 2010. Most of the records are for the collared earthstar (*Geastrum triplex*) one of the most frequent of the 18 earthstar species known from Britain and Ireland (Pegler *et al.*, 1995; Buczacki *et al.*, 2012). Collared earthstars are characterised by the development of a collar around the spore sac as the pericarp rays reflex and split when the earthstar matures (Fig. 1). As noted by O'Reilly (2011), a well-defined white halo encircles the spore sac aperture of *G. triplex* allowing identification of immature specimens without collars (Fig. 2).

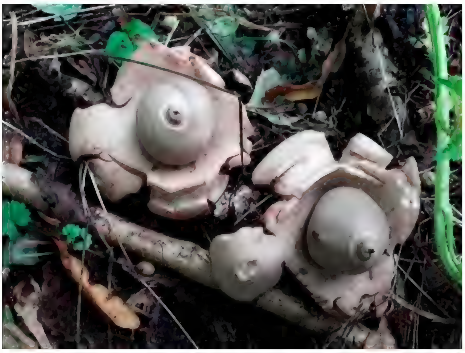

Fig. 1. Mature collared earthstars (*Geastrum triplex*), around 10 cm diameter, showing cracking of pericarp to form a saucer-like collar; Pollok Park, Glasgow, Scotland, October 2019. (Photo: M. O'Reilly)

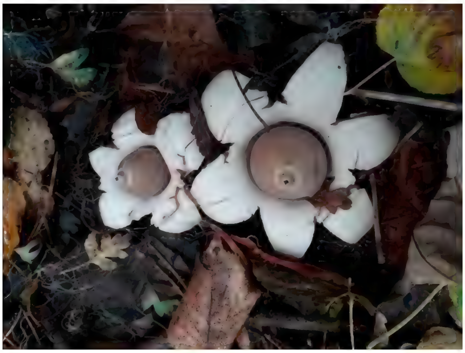

Fig. 2. Immature collared earthstars (*Geastrum triplex*), around 10 cm diameter, without collar but showing distinct spore sac halo; Pollok Park, Glasgow, Scotland, October 2018. (Photo: M. O'Reilly)

However, another earthstar species has also been reported recently from the Glasgow area. In August 2014, the sessile earthstar (*Geastrum fimbriatum*) was photographed in Queen's Park by John McOwat, a local naturalist, and the photos forwarded to GNHS.

Unfortunately no details of the precise location in Queen's Park were provided so the *G. fimbriatum* site could not be revisited. The following May, a further find of old specimens of *G. fimbriatum* was made by Mr McOwat at Strathclyde Country Park, North Lanarkshire, by the Clyde Walkway, just south of the A723 bridge (NS737561).

Although CAFG had undertaken a fungus foray in Queen's Park in November 2013, no earthstars were recorded. However, on 24th August 2019, CAFG carried out another fungus foray and on this occasion sessile earthstars were discovered on the northern side of the park in a small patch of wood between the bandstand and the drive-through road (NS5801362186). Approximately 25 specimens were counted within an area of leaf litter around 3 m^2, at the base of an alder (*Alnus glutinosa*) and partly concealed beneath an evergreen bush. The *G. fimbriatum* specimens look quite similar to *G. triplex* but the reflexing pericarp rays do not split to form a collar in mature specimens and they lack the distinct spore sac halo (Figs. 3, 4).

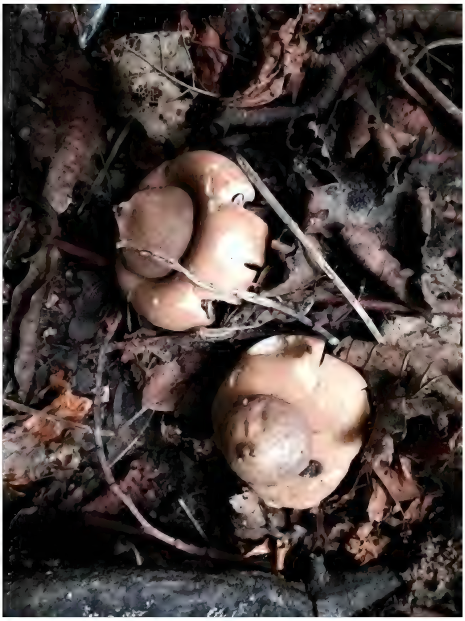

Fig. 3. Mature sessile earthstars (*Geastrum fimbriatum*), around 6 cm diameter, part lateral view showing reflexed pericarp; Queen's Park, Glasgow, Scotland, August 2019. (Photo: M. O'Reilly)

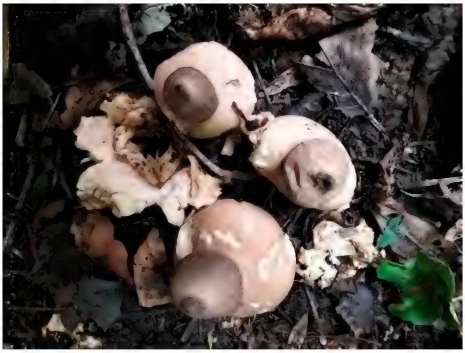

Fig. 4. Mature sessile earthstars (*Geastrum fimbriatum*), around 6 cm diameter, showing lack of spore sac halo; Queen's Park, Glasgow, Scotland, August 2019. (Photo: M. O'Reilly)

Thirteen of the *G. fimbriatum* specimens were subsequently measured. The maximum spread of the pericarp rays was 4.5-9.0 cm (mean 6.5 cm), and the diameter of the spore sac was 2.0-3.0 cm (mean 2.4 cm). Hence the largest *G. fimbriatum* overlap with the size range of 7-10 cm quoted by Buczacki *et al.* (2012) for *G. triplex* and immature individuals of these two species could be confused. However, the characters cited above are usually sufficient to distinguish *G. fimbriatum*. Fortunately both species normally occur in groups allowing a range of specimens to be examined.

Just a few days later, on 28th August 2019, another site in Queen's Park site was checked, near Camphill House (NS57626217). This was where giant puffballs had been seen previously (O'Reilly, 2018). Although no puffballs were observed this time, ten unopened earthstars were discovered. These resemble plant bulbs protruding from the leaf litter and are usually quite difficult to spot (see Fig. 1 in McInerny, 2019). The earthstar "bulbs" did not open until a month later revealing them to be the first record of *G. triplex* from the park. On that same day (23rd September 2019) shortly after leaving the park and while waiting in a traffic queue on Langside Drive, the author noticed another new colony of earthstars on a shady bank next to the Langside Station (NS5741460995). On closer examination these also proved to be *G. triplex* with a total of 31 earthstars spread over the embankment.

Whilst some earthstars may be camouflaged or concealed by leaf litter, once the fruiting bodies are opened they may be quite conspicuous with the paler rays contrasting somewhat with the surrounding leaf litter or bare earth. They are quite persistent and may last several months, enabling them to be observed and counted long after their initial appearance. Over recent years the author has re-visited some of the collared earthstar sites in Glasgow and undertaken counts. A total of 15 counts have been made at five different locations (Table 1). At most sites the earthstar groups were found within a radius of just a few square metres, although in Victoria Park they were spread a little

Location	NGR	Date	Count
Victoria Park	NS54056728	29/09/2017	25
Victoria Park	"	28/12/2018	40
Kelvinbridge	NS57486700	06/09/2019	50
Kelvinbridge	"	10/08/2014	15
Kelvinbridge	"	13/01/2019	34
Kelvinbridge	"	09/09/2019	20
Bellahouston Park	NS55266387	25/10/2014	5
Bellahouston Park	"	05/09/2019	14
Pollok Park	NS55236621	07/11/2010	11
Pollok Park	"	30/10/2011	8
Pollok Park	"	12/10/2016	23
Pollok Park	"	21/10/2018	10
Pollok Park	"	05/09/2019	22
Muirend	NS57205967	13/11/2016	28
Muirend	"	13/10/2019	10

Table 1. Collared earthstar (*Geastrum triplex*) counts at five selected locations around Glasgow, Scotland. For intervening years without counts no site visit was made. Note the counts at Victoria Park in December and Kelvinbridge in January represent old specimens from the previous autumn.

further and at Muirend they were stretched about 50 m along the length of a hedgerow. The abundance at sites ranged from five to 50 earthstars. It is evident from even these few observations that the colonies are long lived with earthstars reappearing in the same location year after year. The earthstars at Bellahouston and Kelvinbridge appear to have lasted at least six years, whilst those in Pollok Park are still going strong at the same spot after ten years.

Although the collared earthstar is apparently becoming commonplace around Glasgow, the sessile earthstar is still a relative rarity. The National Biodiversity Atlas shows only nine occurrences for *G. fimbriatum* in Scotland, mostly old records, scattered over the Lothians, Renfrewshire and Ayrshire, and a single record near Tayport, Fife (NBN, 2020). A review of records in the Fungal Records Database of Britain and Ireland adds only one other Scottish site near Perth, Perth and Kinross (FRDBI, 2020). However, there are several hundred records across the U.K. and the basidiomycete checklist describes it as occasional but widespread in the British Isles, associated with nine broadleaf and seven conifer tree taxa (Legon & Henrici, 2020). It is not clear why earthstars seem to have appeared and spread in the Glasgow area.

The fungi of Glasgow's parks have been well studied in the past (Marshall, 1979) so it seems unlikely that such a distinctive species would have been overlooked. The extensive use of bark mulches may possibly play a role or perhaps climate change could be involved, but more detailed studies would be needed to help understand fungal distribution changes. It is hoped that raising awareness of these interesting fungi will encourage naturalists to look out for further records and perhaps additional earthstar species will be found in the area.

Determination of other species will require careful examination. Confusion could arise with the crowned earthstar *G. coronatum* and the rosy earthstar *G. rufescens* and the two species described here. The colour of the gleba (spores and sac contents) is different in all species, as is the size and ornamentation of the spores. Overall size is very variable in all species, and several species, including *G. fimbriatum*, can occasionally crack to produce collars. As many earthstars are rare and some are red listed, collection of specimens should be avoided, and *in situ* examination (and photography) is recommended for identification purposes. Recent genetic studies indicate that several European earthstar species, including *G. triplex*, may be hiding unrecognised cryptic species (Kasuya *et al.*, 2012; Jeppson *et al.*, 2013).

Thanks are due to Richard Weddle for providing GMBRC records, Dick Peebles for leading the CAFG forays and to Stephen Mitchell for finding the sessile earthstars in Queen's Park in 2019. Thanks also to an anonymous reviewer for improvements to the text.

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Blepharidopterus diaphanus (Kirschbaum, 1856) (Heteroptera: Miridae) and *Ichneumon stramentor* (Rasnitsyn, 1981) (Hymenoptera: Ichneumonidae) new to Scotland, amongst other notable invertebrates discovered at RSPB Scotland Loch Lomond during summer 2019

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RSPB Scotland Loch Lomond is a 237 ha reserve at the south-east corner of Loch Lomond, Scotland (VC86 and VC99). It was acquired by the RSPB in 2012 and includes part of the Loch Lomond National Nature Reserve. The reserve contains a wide variety of habitats, including ancient woodland, bog/fen, ponds and sandy beaches, and is already known to host some rare invertebrates, including the weevil *Bagous lutulentus* and the great otter spider *Pirata piscatorius*.

During May to August 2019, as a residential volunteer, I spent roughly 120 h over the four months carrying out casual surveys of various habitats on the reserve, principally with a sweep-net but also with an aquatic survey net and plastic trays for surveying ditches. When identification was not possible in the field, specimens were taken back to the reserve office to study microscopically, and some specimens were sent to national or vice-county recorders for identification. The final total of 513 species (mainly invertebrates) new to the reserve included a number of unusual species, a few interesting examples of which are described in this Short Note.

RSPB Scotland Loch Lomond is well-known for its wetland plant diversity, and it was pleasing that several invertebrate species recorded as new to the reserve during the 2019 survey were specialists associated with wetland plants, such as the flea beetle *Longitarsus holsaticus* (found here on marsh lousewort (*Pedicularis palustris*)), the sawfly *Athalia scutellariae* (Fig. 1) (whose striking white-pimpled black caterpillars were found on skullcap (*Scutellaria galericulata*)), and the leafhopper *Macrosteles septemnotatus*, a locally distributed species in the U.K. associated with meadowsweet (*Filipendula ulmaria*).

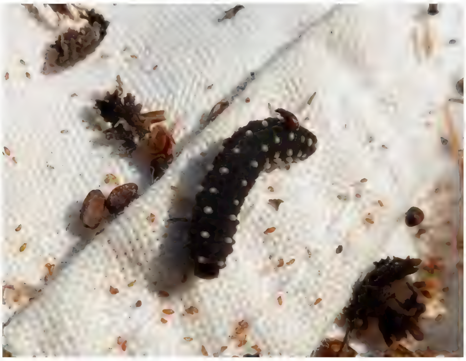

Fig. 1. A larva of the sawfly *Athalia scutellariae* found on skullcap *Scutellaria galericulata* in 20 Acres, RSPB Scotland Loch Lomond, on 20th August 2019. The larva is *ca.* 15 mm long. A marsh beetle (*Cyphon* sp.) is "piggy-backing" on the sawfly. (Photo: S. Buckton)

Although regular moth-trapping on the reserve means that its moth fauna is reasonably well-known, during this survey three species new to West Dunbartonshire (VC99) were found. Brussels lace (*Cleorodes lichenaria*; Fig. 2), a lichen-feeding geometrid which is locally distributed in Scotland, was caught in a Robinson trap outside the volunteer farmhouse in late June. The British population of Brussels lace decreased by 33% from 1968 to 2002, unlike many other lichen-feeding moths whose populations increased over this period (Fox *et al.*, 2006). A winter oak groundling (*Carpatolechia decorella*) was caught by sweep-netting the ground vegetation of western Ring Wood (ancient oak woodland) in late July. This gelechiid micro-moth is listed as Nationally Scarce B (Davis, 2012) and overwinters as an adult (lending the moth its common name); the larvae presumably feed on oaks (*Quercus* spp.) in Ring Wood. Lastly, an Indian meal moth (*Plodia interpunctella*) was found inside the volunteer farmhouse in mid-August; this is a local introduced pest of stored grains.

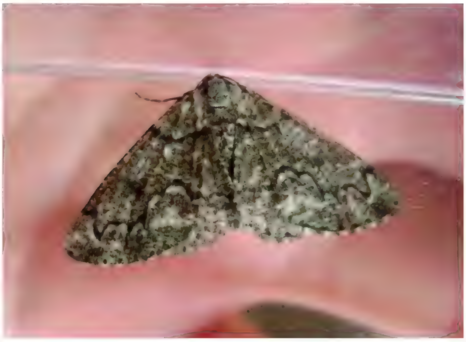

Fig. 2. The geometrid moth Brussels lace (*Cleorodes lichenaria*) caught in a Robinson trap near the volunteer farmhouse, RSPB Scotland Loch Lomond, on 30th June 2019: the first known record of this species for VC99. The wingspan is *ca.* 35 mm. (Photo: S. Buckton)

Perhaps the most interesting find was a pale greenish mirid bug (Fig. 3) swept from a white willow (*Salix alba*) along the bank of the River Endrick in Snipe Flats at NS44008792 (Fig. 4) on 8th August. This was identified as *Blepharidopterus diaphanus* (Kirschbaum, 1856) by Petro Pynnönen, who is familiar with the species from Finland. The British status of *B. diaphanus* is described as "widely scattered" (Bantock & Botting, 2018); Jim Flanagan (National Organiser of the Plant Bugs & Allies Recording Scheme) noted that this record was the first for Scotland, a view supported by the absence of *B. diaphanus* in the Scottish Invertebrate Records Index (SIRI). *B. diaphanus* is associated with white and weeping willows (*Salix* spp.). The new Scottish record of *B. diaphanus* is a major extension from the recent, next-most northerly record from weeping willow in the grounds of Durham University, England (Jim Flanagan, pers. comm.), which is itself a big advance from the most northerly record in the NBN Atlas at the time of writing, which is just outside Derby, England. Soon after the Scottish record, *B. diaphanus* was found on white willow in County Armagh, a first record for Ireland (Brian Nelson, pers. comm.). At present it is not clear if this species has been widely distributed but under-recorded, or if its range has been recently expanding.

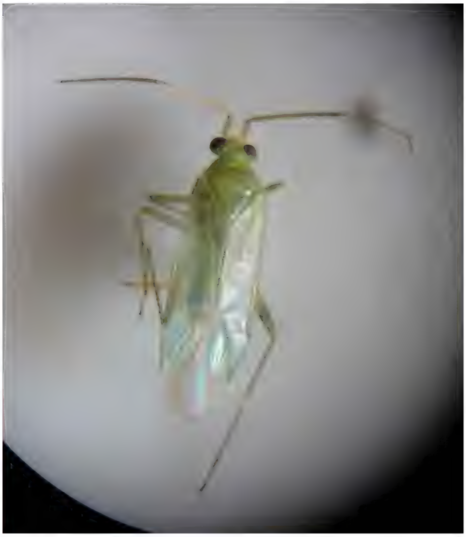

Fig. 3. The mirid bug *Blepharidopterus diaphanus* swept from white willow (*Salix alba*) in Snipe Flats, RSPB Scotland Loch Lomond, on 8th August 2019: the first known Scottish record of this species. The bug is *ca.* 5 mm long. (Photo: S. Buckton)

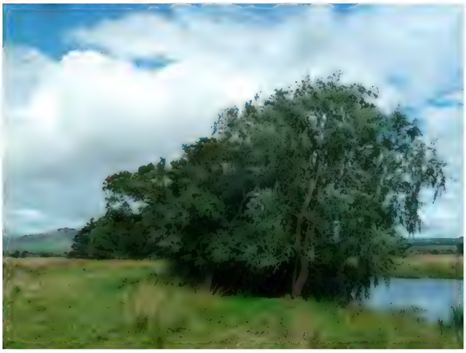

Fig. 4. The white willows (*Salix alba*) along the bank of the River Endrick in Snipe Flats, RSPB Scotland Loch Lomond, which yielded the first Scottish record of the mirid bug *Blepharidopterus diaphanus*. (Photo: S. Buckton)

There were two other finds of particular note. The first was the leafhopper *Metidiocerus rutilans* (Fig. 5), a female of which was swept from a grey willow (*Salix cinerea*) in Reserve Compartment 28 (NS430871), an area of bog, on 13th August. This record is the first *M. rutilans* from mainland Scotland, since it was previously known only from the island of Skye (Alan Stewart, pers. comm.). The species is absent from SIRI.

M. rutilans is a local species associated with sallows (*Salix* spp.) and often overwintering on pines (*Pinus* spp. (Bantock & Botting, 2018). It is found primarily in southern Britain; there are no previous records for mainland Britain north of a line running west to east to the Humber estuary in England (Alan Stewart, pers. comm.).

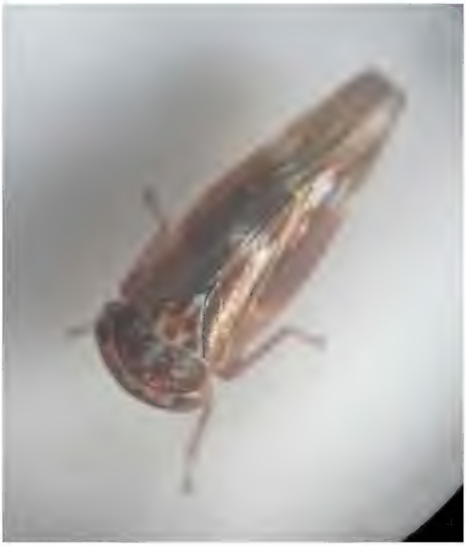

Fig. 5. The leafhopper *Metidiocerus rutilans*, swept from grey willow (*Salix cinerea*) in Reserve Compartment 28, RSPB Scotland Loch Lomond, on 13th August 2019: the first record of this locally distributed species in mainland Scotland. The leafhopper is *ca.* 5 mm long. (Photo: S. Buckton)

The second notable find was surprising, not because the species in question is rare, but because it is common. On 7th June, a female *Ichneumon stramentor* – a handsome black-and-yellow ichneumonid wasp parasitising the pupae of moths such as large yellow underwing (*Noctua pronuba*) and setaceous Hebrew character (*Xestia c-nigrum*) (Prehn & Raper, 2017) – was caught from a huge mature oak (*Quercus* sp.) near Shore Wood (NS427878). This species was new to the Scottish checklist of Ichneumonidae (Broad, 2016) (which included searches of the Natural History Museum collection), absent from SIRI, and confirmed as absent from the original invertebrate collections held by National Museums Scotland and World Museum Liverpool. There is a pre-existing record of *I. stramentor* on *iRecord* (https://www.brc.ac.uk/irecord/) from Handa Island, Sutherland, on 20th July 2013, but no photographs were provided and the recorder was not known to Gavin Broad, making the record unverifiable (Gavin Broad, pers. comm.). Hence, despite *I. stramentor* being common and widespread south of the border in England, and likely widespread in Scotland too, the Loch Lomond record apparently represents the first verified *I. stramentor* from Scotland.

I would like to thank Alan Kerr for assisting in the identification of and/or verifying my VC99 moth records, and Ashleigh Whiffin, Mark Shaw and Tony Hunter for checking invertebrate databases and collections on request.

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BOOK REVIEWS

Birds in Winter

Roger F. Pasquier
Princeton University Press, 2019. 304 pages, hardback with black & white line drawings. ISBN 978-069-117855-4.
£24.00

This is a scholarly book (the references alone occupy more than 30 pages) but an eminently readable one. It sets out to examine that most challenging part of the avian year. Whether they migrate to avoid it, or remain to endure it, for birds “winter” actually begins in late summer as they prepare for it, and lasts until early summer of the following year in that it may determine their subsequent breeding success.

Of the ten chapters, two deal with how birds “know” that winter or spring are on the way, two deal with migratory species and how they select habitat and organise themselves in relation to the resident inhabitants they encounter, and two (“Survival” and “The Winter Day”) focus on those that remain and how they cope. Two final chapters on “Conservation” and “Climate Change” deal with topics such as habitat loss, invasive species, pollution, shifts in winter range and the possibility of accelerated evolution.

Pasquier is not afraid to take digressive paths and, like all broad-ranging reviews, this book throws up questions and examples which grab our attention. Do birds moult before or after migration? (Answer: both and, extraordinarily, even during). What climatic factors determine winter mortality in resident species? (Answer: temperature is much less important than snow cover or rainfall). Do some individuals like their winter quarters so much that they decide to stay? (Answer: yes, but mainly juveniles for one year only). At one point, the author invites us to spare a thought for Buenos Aires where the resident wader population must not only accommodate northern migratory shorebirds but then provide for Patagonian species coming from the south to avoid the austral winter, so that three distinct populations may briefly overlap to compete for resources.

There are two caveats. First, there is scant attention paid to “clocks” or to the mechanisms by which migratory species actually find their way. Perhaps the author feels that the dust has not yet settled on navigational cues and spatial memory. Second, Pasquier is an ornithologist at the American Museum of Natural History. It is not surprising, therefore, that at least half of the examples used are New World species. Nevertheless, the underlying principles will usually translate to species we are more familiar with, and to travelling ornithologists (and those interested in U.S. rarities that turn up in Europe by mistake) it opens many doors. The book is illustrated with charming line drawings by Margaret La Farge and these greatly complement an already impressive work.

At first sight, this may seem an off-beat topic, but it is well served by the author who clearly demonstrates that it genuinely deserves a whole book, and that it is not off-beat at all. It is too dense for devouring at a single sitting, but is a volume for dipping into, digesting and returning to. I recommend it to the serious birder.

A.P. Payne

Field Guide to the Ladybirds of Great Britain and Ireland

Helen Roy & Peter Brown, illustrated by Richard Lewington
Bloomsbury Wildlife, London, 2018. 133 pages, paperback, with colour photographs and illustrations. ISBN 978-1-4729-3569-4.
£25.00

Their bright colours and patterns of spots make ladybirds (Coleoptera, Coccinellidae) a popular and generally easily recognised group of beetles. They are not bugs, despite the U.S. name "ladybug", though there a few true bugs that can be mistaken for ladybirds. Of the 47 species in the U.K., 29 have been recorded in Scotland, though of those 29 there are no recent records of the false-spotted (*Hyperaspis pseudopustulatus*), and the occurrences of Adonis' ladybird (*Hippodamia variegata*) probably represented vagrants. However, not all of the 47 are instantly recognisable as ladybirds in that some have cryptic coloration, and are rather small (1.0-3.5 mm in length – the 1 mm species is aptly named the "dot ladybird" (*Stethorus pusillus*)).

This and the book reviewed below are largely complementary to each other: the *Field Guide*, as its name suggests, is the more scholarly (though still very accessible) and is indispensable to the serious surveyor (or even casual photographer) in that it gives detailed accounts of adults and larvae of all 47 species. The *RSPB Spotlight* is in a generally more "readable" style (though certainly not lacking in academic "weight") – it does not give systematic accounts of the species, though there are illustrations of most of the larger ladybirds, spread throughout the book; and it is organised by themes, such as ladybirds in cultural contexts.

As would be expected from the authors, who are the organisers of the U.K. Ladybird Survey (www.coleoptera.org.uk/coccinellidae/home/), the *Field Guide* is both well-informed and up to date, all the more so as Helen Roy holds a research post at the Centre for Ecology and Hydrology and is visiting Professor in the School of Biological Sciences, University of Reading.

The book fills a real need, as there was previously no comprehensive guide to identification of U.K. ladybirds beyond the dichotomous keys in *Ladybirds* by Roy *et al.* (2013, Pelagic Publishing). The latter book lacked comprehensive colour illustrations and the information in it about habitat and distribution was separate and generalised, whereas in the *Field Guide* all these aspects are grouped together with the illustrations, U.K. and Ireland distribution maps, and U.K. conservation status. A dichotomous key is largely redundant given that possible confusion species are also mentioned where necessary, and there are pictorial keys including an "at a glance guide" to all 47 species, and some welcome pictorial keys to groups of very similar ladybirds, such as black ones with two red spots - also to species which might easily be confused for ladybirds.

I mentioned a key would be "largely" redundant, and this brings me to my niggle: ladybird species are notoriously variable in appearance, particularly the 2-spot ladybird (*Adalia 2-punctata*) and 10-spot ladybird (*A. 10-punctata*), and though a handful of possible variations of the most variable species are illustrated – including teneral (immediately after emerging from the pupa) forms of the 10-spot, which can puzzle the beginner – these are by no means exhaustive, as testified by the earlier *Ladybirds* book (mentioned above), and even more possibilities are shown and discussed in the authoritative book in the New Naturalist series *Ladybirds* by Majerus (1994, HarperCollins).

Another useful feature is that the authors have proposed English names for some of the previously un-named species, i.e. most of the inconspicuous species in the subfamily Coccidulinae such as the species of the genera *Rhizobius*, *Scymnus* and *Nephus*. This may well make these species more accessible and therefore better studied, which could encourage recording by "citizen scientists", another of Helen Roy's special interests.

Of the 47 British species some are relatively recent arrivals such as the bryony ladybird (*Henosepilachna argus*) and the harlequin ladybird (*Harmonia axyridisi*), some species previously confined to England are spreading into Scotland, and potential future additions are also listed. Other sections discuss the general features and life-history of the group; the species that may be found in the various habitat types and in the regions of the U.K. – including an entry on Central Scotland (with a photograph of Fannyside Moss near Cumbernauld); plant species that are good for ladybirds (Leyland cypress among them!); and a short but very useful list of "further resources" – books, websites and local record centres.

I already have the *Field Guide* and have found it useful over the past year.

In summary, this is an indispensable resource for anyone wishing to take ladybirds seriously.

R.B. Weddle

RSPB Spotlight: Ladybirds

Richard Comont

Bloomsbury Wildlife, London, 2019. 128 pages, paperback with colour photographs. ISBN 978-1-4729-5585-2.

£12.99

The author of this book has also contributed to the *Field Guide*, reviewed above, and is one of the co-authors of *Ladybirds* by Roy *et al.* (2013, Pelagic Publishing). The distinguishing feature of the book is that it is organised by themes, and is more adapted to continuous reading for enjoyment rather than for reference, but there is an index if reference is required.

It begins with customary introductory sections on what characterises ladybirds and their feeding and lifecycles. This book also highlights their status as cultural icons and, in a section headed "Ladybirds Across Time and Space", outlines the evolution of insects and beetles in particular as evidenced by the fossil record, though the earliest undisputed evidence of ladybirds is from insects preserved in amber *ca.* 50 million years ago. This section is followed by an account of their presence in Britain starting with archaeological evidence dating back *ca.* 43,000 years, though the present population dates back to the period after the last ice-age but continues up to the present day - at least five species have become established in the past couple of decades.

There is also a section on ladybirds worldwide which emphasises their ability to occupy almost every terrestrial habitat from mountain tops to deserts (there is one British species called the water ladybird which lives on emergent vegetation, but should it fall into the water it has evolved the ability to swim to land!). Sections on diet follow (some species are vegetarian), their behaviour, insect parasites and fungal and bacterial infections, and no fewer than four pages on the "Horrible Harlequin".

But perhaps uniquely this book includes a section entitled "Cultural Connections", which opens appropriately enough with the cover illustration of *Goldilocks and the Three Bears* published by Ladybird Books. It mentions the folkloric significance of ladybirds worldwide, along with the various names given in different languages (there is an illustration of a German Renaissance painting by Matthias Grünewald - "Madonna im Gärtchen", which shows Mary wearing red rather than the customary blue, so referencing the German name for the group - Marienkäfer – Mary beetles). There are accounts of ladybird legends, songs, fiction and poetry, marketing logos, and in popular culture (I didn't know about the animated superhero Marinette who fights the villainous Hawk Moth – if you want to know her rousing battle slogan you'll have to read the book, or watch one of the films).

The book also includes information on how to find and watch ladybirds, and gardening for ladybirds. It concludes, like the *Field Guide*, with further reading and resources and a list of current U.K. species. The text is amply endowed with excellent photographs of many of the U.K. species (and some of the "lookalikes"). However, it seems obligatory for a reviewer to find a niggle or two: mine are that the list of "inconspicuous species" includes *Platynapsis luteorubra* which in the *Field Guide* is listed among the "conspicuous species"; Comont also includes one ("conspicuous") species that is currently found only in the Channel Islands (*Calvia decemguttata*) and which is not included in the 47 species in the British list (and therefore the *Field Guide*), presumably because it is mentioned in passing on page 7. These matters are unlikely to trouble the vast majority of readers.

I concluded the review of the *Field Guide* with "an indispensable resource for anyone wishing to take ladybirds seriously". I'd say the *Spotlight* book, by contrast, is a useful and interesting resource for anyone with any interest in ladybirds at all, and should even spark interest among those who previously had none. An excellent complement to the *Field Guide*, and a worthy addition to any natural historian's library; it's now on my birthday "wish list".

R.B. Weddle

Landfill

Tim Dee
Little Toller Books, Dorchester, 2018. 256 pages, hardback. ISBN 978-19-0821-362-4.
£16.00

This book is made up of an eclectic mixture of seemingly very different topics and subjects. The author, a long-term ornithologist, has slipped into the "bad" habit of studying seagulls, which show fascinating variation and complexity in their plumage, making their identification a satisfying intellectual challenge (this reviewer suffers from the same "malady").

But Tim Dee takes this exercise further by exploring the relationship of gulls with humans, not only in our shared existence in an increasingly polluted world, but also how humans have described and catalogued the various species. Part of the fascination of identifying gulls is that their taxonomy is in a state of flux, with birds variously described as species, subspecies or even hybrids between the two. This likely in part reflects that the birds are moving to new areas and changing their distribution, following the influence of man on the environment, which results in their speciation being a relatively recent and possibly on-going process, at least for some taxa.

The author's narrative follows him travelling through the U.K. studying gulls and speaking to bird-watchers who study and observe them, along with others interested in natural history and the relationship of humans and birds.

For those interested in our interaction and understanding of natural history, I recommend this book as a "different" read.

C.J. McInerny

Britain's Day-flying Moths: a Field Guide to the Day-flying Moths of Britain and Ireland (2nd Edition)

David Newland, Robert Still & Andy Swash
Princeton University Press, 2019. 232 pages, paperback with colour photographs and distribution maps. ISBN 978-0-6911-9728-9.
£17.99

At first sight this book might seem an oddity, since most people assume that moths fly by night. However, as this book confirms, there are plenty of day-flying moths, although the authors have extended their coverage by including moths which are "easily disturbed" by day. The book is part of the *WILDGuides* series published by Princeton University Press in conjunction with Butterfly Conservation. Described as a field guide, it will fit in a large pocket (and easily in a rucksack) and has a firm, water-resistant cover; it is on good quality, glossy paper and weighs 560 g.

The book begins with a section on general moth biology, life cycles and taxonomy. I was struck by a section on habitats and the number of species found in them, and there are related ones on gardening for moths and larval food plants as related to moth families.

The book deals predominantly with macro-moths, but includes some micros. The entries are arranged by family. Each species is illustrated with one or two large photographs in a resting, natural pose and a brief description covering key identifying features, confusion species, a distribution map and larval food-plants. There is also information on status in the U.K. and flight season. The section on clearwings (*Sesiidae*) includes a useful table of pheromone lures for each species and when to use them. The book ends with a table collating all the information for each species and sections on conservation legislation, biodiversity action plans and recording, as well as lists of books and websites.

If you are a confirmed lepidopterist, this will not be your primary source book, but you will almost certainly want to own it. It will also be of use to those with a passing interest in moths they might encounter during a field trip or a day out in the country. It has clearly been successful enough to merit a second edition. The original publication came out in 2013; this second edition has eight extra pages and has gone up four pence in price.

A.P. Payne

Saltmarsh

Clive Chatters
Bloomsbury Natural History, London, 2017. 384 pages, hardback. ISBN 978-1-4729-3359-1
£35.00

Saltmarsh is the fifth volume in the British Wildlife Collection by Bloomsbury Press. The remit of this profusely-illustrated series - to provide a reference source on varied aspects of British Wildlife - is fully satisfied by Clive Chatters' comprehensive treatment of saltmarshes. This is a subject which he describes as forming a backdrop of much of his life, 35 years of which he has spent working as a naturalist and nature conservationist. This volume confirms how well equipped he is to deal with this diverse and dynamic environment and its place within the history and practice of conservation. Indeed, I was surprised at the breadth of subject material he included, with exceptional coverage of geology, archaeology, history and (especially) conservation, in illuminating detail I did not anticipate.

The first three chapters provide us with a definition of what constitutes a saltmarsh. Not all are coastal; inland saltmarshes also exist where the underlying rocks release salt. Clearly, even left entirely to natural forces, saltmarshes are very dynamic and vulnerable environments, but human interaction has played a huge role in their shape, form and continued existence in so many cases. In these chapters and throughout, photographic illustrations of plants, animals, habitats and landscapes are excellent.

Chapters 4 to 12 deal with individual saltmarshes in detail, from the Highlands and Islands of Scotland, to the Solway Firth, marshes in Wales, the Humber, Severn, London and Southampton. There is fascinating background information about each site covering not just the natural history, but the geology and all the human interaction factors and their interplay with the saltmarsh over the centuries. It is interesting to think of London largely being built on the saltmarshes of the Thames and "The Legacy of the Solent Saltworks" (Chapter 11).

The next chapters cover conservation issues. The human impact on saltmarshes (the wish to alter, eliminate or conserve) largely depended on their productivity in human terms at each point in time. Clive Chatters looks at this and leads into a detailed description of the development of the conservation movement in recognising saltmarshes as having intrinsic value as dynamic, biodiversity habitats and landscapes. He describes the development of conservation at local to international levels, from the concept of conservation, to legislation and regulation. The making of National Nature Reserves, National Parks, then Local Nature Reserves is outlined and illustrated as is the development of Sites of Special Scientific Interest. The fragility and biodiversity of saltmarshes was recognised in these designations with 60 sites in Britain relating to saltmarshes being covered by protective legislation. Tables of protected species and the two Appendices A and B cover much detail protect sites. "Rejuvenation" completes this section on a note of optimism.

As an addition to The British Wildlife Collection, *Saltmarsh* gives excellent coverage of a very complex and dynamic subject. It is a well-rounded volume, particularly rich with respect to botanical detail and conservation issues. However, the general natural history enthusiast, professional and amateur, has much to learn from Clive Chatters' extensive background research and vast practical experience expressed in a thought- provoking and very readable fashion.

A. Moss

The Glasgow Naturalist (2020) Volume 27, Part 2, 92-95

OBITUARY

Ronald Matthew Dobson (8th December 1929 – 21st November 2019) Photograph taken in his retirement. (Photo: the Dobson family)

Dr Ronald Matthew Dobson devoted a large part of his life to studying the natural world as a keen naturalist and a professional biologist. His published work reflects these two strands over a range of subjects within natural history and applied entomology. A bibliography of his publications has been compiled (Appendix).

Early career

Ron was brought up in Blackburn, Lancashire, England and after attending the Queen Elizabeth Grammar School there, he was awarded a scholarship to study Zoology at King's College, University of Cambridge on an accelerated war-time degree, 1943-1945, that required him to work thereafter for the Government. His career in entomology began with a series of roles as an Insect Infestation Inspector for the Ministry of Food from 1945 to 1947, continuing with the Department of Agriculture for Scotland, based in Glasgow up to 1949. In that year he started as a post-graduate entomology student with the Imperial College of Science and Technology, London and conducted research on flea beetles of the genera *Phyllotreta* and *Psylliodes* (Coleoptera, Chrysomelidae), serious pests of cruciferous vegetable crops, at the University of London's Wye College field station in Kent during 1950-1953. It was there, while studying the living insects in the field, that he met Ruth Nash who was working on insecticides in the Chemistry Department. Her professor introduced them, saying: "This is Miss Nash. I want you to help her; not too much help, mind". Despite Ruth taking up a post in faraway Edinburgh, their association developed into courtship and they married in 1955, by which time Ron had moved to a research post at Rothamsted Experimental Station in Harpenden, Hertfordshire. Details of their shared lives are given in an earlier article about Ruth ([Dobson], 2016), the text of which was provided by Ron but which appeared anonymously. While at Rothamsted, during which time several articles on the results of his Ph.D. had begun to appear, his detailed taxonomic studies on the stored product pests of the genus *Carpophilus* (Coleoptera, Nitidulidae) produced a series of papers. In parallel, work started on the biology and control of the wheat bulb fly (*Leptohylemyia coarctica*) that continued with papers on the subject up to 1964. A film was made featuring Ron's work on this pest and can be accessed at the Pathé News website: https://www.britishpathe.com/video/wheat-bulb-fly/query/Rothamsted.

At the University of Glasgow

After 1959, having reached the rank of Senior Scientific Officer at Rothamsted, Ron moved to the University of Glasgow, Scotland as Lecturer in Zoology where he progressed to a Senior Lectureship in 1974, retiring in 1995 (though continuing in an honorary capacity for some years). In addition to continuing the wheat bulb fly research, pest craneflies (Diptera, Tipulinae) with their leather jacket larvae were investigated in collaboration with postgraduate students. Ron also got involved with research on domestic dust mites (Arachnida, Pyroglyphidae), causative agents of respiratory diseases in humans.

At the University of Glasgow, Ron had joined a small team (Alex Hill, Douglas Cochrane and Alistair Fraser) teaching an honours degree programme in Agricultural Zoology, focusing on pests and their management. In addition, a postgraduate diploma course (eventually up-graded to a Masters degree) was offered, mainly aimed at overseas students. When Ron started, zoology, both pure and agricultural, attracted small numbers of students (in the seven years after Ron joined, there were on average five graduates per year in zoology and 2.5 in agricultural zoology), but numbers in pure zoology expanded rapidly in the 1970s (22 in 1973), with associated growth in staff numbers, while agricultural zoology remained static (four students in 1973). Student numbers might have been small, but a full complement of lectures and practical classes still needed to be delivered, so teaching loads for the agriculture team were very high. By 1984, when Alex Hill retired (Hancock & Dobson, 2008), the agriculture course was unsustainable. Ron, however, continued to teach, especially on a second year applied zoology course, as well as supervising postgraduates. One of Ron's last Ph.D. students, Matt Colloff, who worked on house dust mites (1982-1985), went on to a successful career in Australia. He has commented that Ron was an excellent supervisor, providing all the skills needed to start on a scientific career (M. Colloff, pers. comm., December 2019).

Ron was the leader for summer Glasgow University Exploration Society staff-student expeditions to South Uist, Outer Hebrides (1962 and 1964) and Portugal (1966). Whereas only limited reports were produced, their existence is immortalised in the collections deposited in the Hunterian Zoology Museum, Glasgow, the Natural History Museum, London, and in the memories of participants (Downie *et al*., 2017).

Scottish Natural history

Ron joined the Glasgow Natural History Society in 1963, soon after joining the University's staff. He was a Councillor for many years, Convenor of the Zoology section 1974-1986, an editorial board member 1964-1983, Editor of *The Glasgow Naturalist* 1984-1995, vice-President three times, and was eventually elected to honorary membership in 2001. He and Ruth (who served many years as librarian), were amongst the most consistent attendees at Society meetings, summer and winter.

From 1978 onwards Ron produced numerous papers on Scottish natural history. The work on Muck was conducted mainly during family holidays, but field data from other places were collaboratively obtained with university colleagues and local naturalists. Some were funded by agencies such as the then Nature Conservancy Council for Scotland and structured to form base-line faunistic accounts, in collaboration with colleagues and friends including Roy Crowson, Walter Edgar, Alex Hill, Geoff Hosie and others. The collections gathered for identification were preserved to act as voucher specimens for the species' records.

Hunterian Zoology Museum connections

Ron was a great friend of, and contributor to, the Hunterian Zoology Museum. He acted as an honorary curator, organising student help in arranging the amalgamation and layout of many of the British insect drawers. Before a post for an entomological curator was established in 1997 he advised on incoming research loan requests. Preserved samples from his own field work were deposited in the collections and so, as a donor, his name is associated with many museum records. Teaching agricultural entomology required samples for laboratory-based demonstration and extensive series of specimens of pests of all kinds were gathered and organised by Ron in hundreds of well-labelled tubes kept in racks. Many of these include medically important insects from around the world, not just disease vectors, that impact on humans and stock animals in a variety of ways. Stored product and household pests are also in this valuable series. Some of the specimens in this part of the teaching collection pre-dated his arrival in Glasgow, but he organised all into a coherent and accessible whole. His appreciation of the value of museum collections arose from his own taxonomic work with *Carpophilus* beetles. His extensive collection of these insects and his manuscript notes recently formed an important research loan to a New Zealand-based student studying the Oceanic fauna (Brown, 2009, 2010). In retirement Ron voluntarily worked through thousands of preserved British beetles (Coleoptera), labelling and identifying them so they could be incorporated into the main series. In addition to this work for the Hunterian, he sent specimens to the Natural History Museum, London numbering eight accessions and a total of 283 insects for inclusion in the U.K. national collections.

Family and interests

Apart from his natural history interests Ron was a devoted family man. He and his wife Ruth "were blessed with five sturdy children who have all distinguished themselves in their chosen fields" to quote a letter from him dated 3rd December 2015. He and Ruth purchased an old schoolhouse on the Ardnamurchan peninsula in north-west Scotland, with great views of the small islands and the Cuillins, and much of their leisure time was spent there, with Ron doing a host of improvement projects. Ardnamurchan was also the centre for their joint work on the natural history of the Muck islands. Ron was a keen aficionado of classical music, especially opera, and he played the violin and viola for many years in amateur orchestras. Another interest was rowing, begun at Cambridge, and continuing in the seas around Ardnamurchan, often solo. The family went to Muck from Ardnamurchan by row boat on some occasions.

Ron died of heart failure in Queen Elizabeth University Hospital in Glasgow on Saturday 21st November 2019. He was nearly 94 years old and lived independently until a few days before his death. He had seven grandchildren and a great grandchild and celebrated a grandson's 18th birthday just a few days before he was taken into hospital. The Glasgow Natural History Society and former colleagues extend their condolences to Ron's family.

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Appendix: A bibliography of publications by Ron Dobson

This list excludes numerous book reviews that appeared in *The Glasgow Naturalist*.

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E. Geoffrey Hancock, J. Roger Downie
& Sarah Higgins

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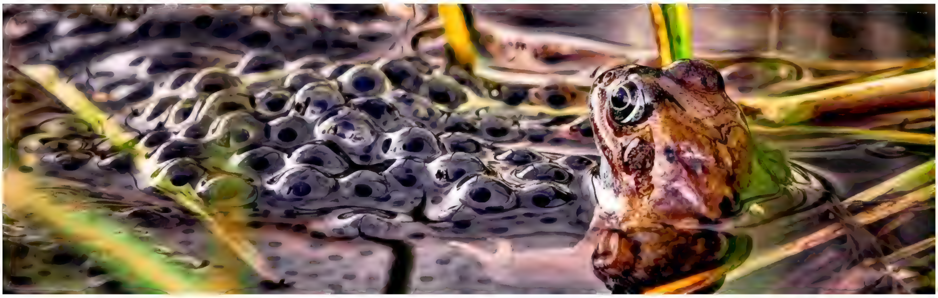
PhotoSCENE 2018-2019

PhotoSCENE Natural History Photographic Competition

The annual PhotoSCENE competition, sponsored by the Glasgow Natural History Society and the University of Glasgow Institute of Biodiversity, Animal Health and Comparative Medicine. It aims to promote interest in Natural History and the work of SCENE (Scottish Centre for Ecology and the Natural Environment, the University's field station at Rowardennan), promote linkage between the Institute and the Society, and provide pictures for publicity. All entrants are thanked for making the effort to enter the competition. Prizes totalling £800 per year have been awarded at the Society's photographic nights. Since the first competition in 2011, and together with talks from members, the competition has provided us with an interesting photographic evening each February. This year there were 71 entries from 20 people.

D.C. Palmar

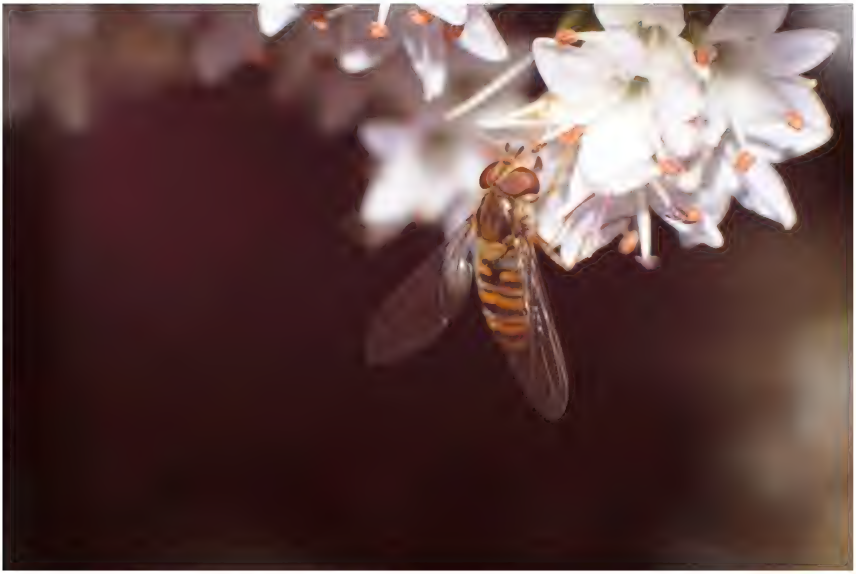
First Prize Winner:



Andy Wilson - Common frog (*Rana temporaria*) with spawn - Holmhills Community Woodland, Cambuslang, South Lanarkshire, Scotland, 5th March 2018, taken with a Canon 5Dlll camera.

Second Prize Winners:

These include the photographs by Thomas MacGillavray and Jonas Gaigr that feature on the front and back covers respectively. Information on these photographs is provided on the inside front cover. The other second prize winners are shown below and on the following pages.



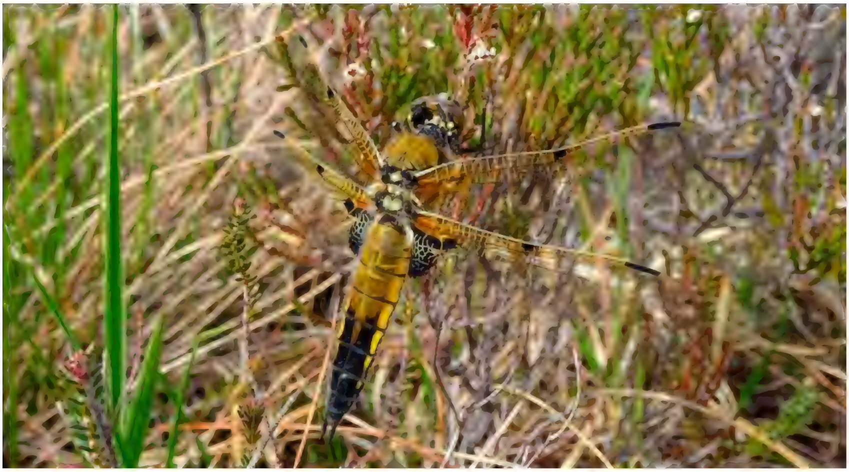
Gabriel Lawson-Duck – Marmalade hoverfly (*Episyrphus balteatus*), Glasgow Botanic Gardens, Scotland, taken with a Sony alpha 3000 camera.

Eric Vaughn Captain Schneider - Bar jacks (*Caranx ruber*), Eleuthera, The Bahamas, January 2019, taken with a Panasonic Lumix camera.

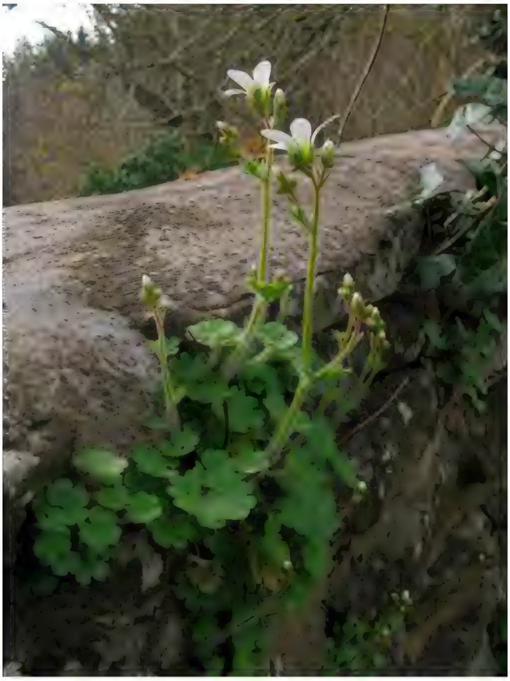
Michelle Bellingham - Elephant hawk moth caterpillar (*Deilephila elpenor*), Erskine, Renfrewshire, Scotland, 15th August 2019, taken with a Samsung Galaxy S8 mobile phone.

Robyn Haggard - Rock pooling, Arran, Scotland, 3rd October 2019, taken with a Huawei P20 mobile phone.

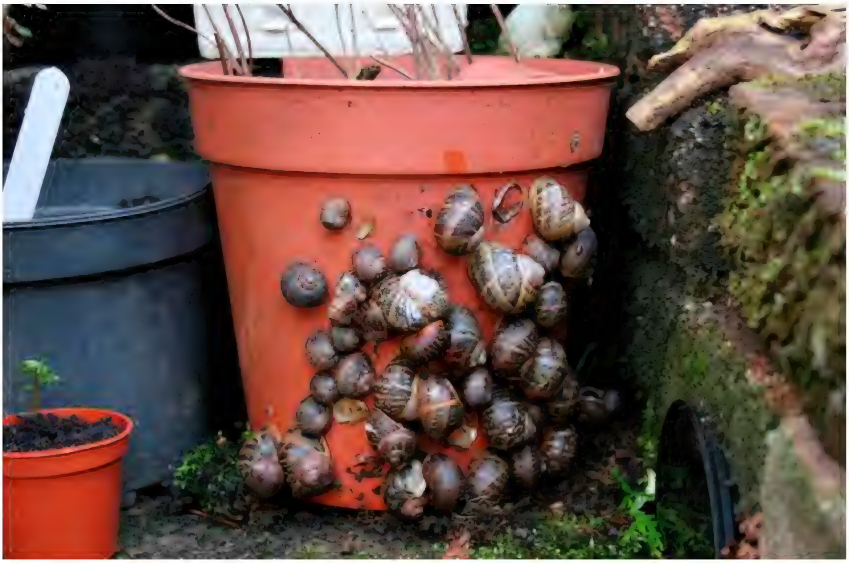
Crinan Jarrett - Leaf-tailed gecko (*Uroplatus* sp.), Reserve Peyrieras, Madagascar, taken with a Nikon D5200 Digital SLR camera.



Jaime Villacampa - Four-spotted chaser (*Libellula quadrimaculata*), bog on the slopes of An Teallach, Northwest Highlands, Scotland, May 2019, taken with a Sony Cybershot DSC-WX350 v2.00 camera.



Sarah Longrigg - Meadow saxifrage (*Saxifraga granulata*), Corra Castle, near New Lanark, South Lanarkshire, Scotland, 13th April 2019, taken with a Canon Powershot A720 IS camera.



Richard Sutcliffe - Garden snails (*Cornu aspersum*), Bearsden, East Dunbartonshire, Scotland, 2nd April 2019, taken with a Canon EOS 20D camera.

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PROCEEDINGS 2018

The lecturer's name and the title of the lecture are given for each meeting, as is the location, which was within the University of Glasgow unless stated otherwise. Joint meetings with other natural history societies are indicated. Most of the meetings were reasonably well attended with the joint lectures being very well attended.

January 9th
Lecture 1: "Freshwater biodiversity in the U.K.: how does Glasgow compare?" from Alan Law. Lecture 2: "The ten o'clock newts: investigating nocturnal patterns of the great crested newt" from Erik Paterson. Boyd Orr Building.

February 13th
Photographic Night. Members' slides or digital slide shows, plus results of the PhotoSCENE competition. Boyd Orr Building.

March 8th
Expeditions Report Back, jointly with the University of Glasgow Expeditions Society. (Most expeditions are supported by the BLB bequest.) Graham Kerr Building.

March 13th
Annual General Meeting, followed by Lecture: "The Water Framework Directive: algal communities and estuarine fish" from Pauline Lang and Myles O'Reilly, Scottish Environmental Protection Agency. Boyd Orr Building.

March 16th
Lecture: "Scottish badgers" from John Darbyshire, jointly with Hamilton Natural History Society and Paisley Natural History Society. Hamilton Old Parish Church Hall.

April 10th
Lecture: "Behind the naturalist's lens: the photographic work and contribution to natural history of Charles Eric Palmar" from David Palmar and colleagues. Boyd Orr Building.

May 8th
Lecture 1: "The aspen project" from Peter Livingstone.
Lecture 2: "An eye for the unusual: the herbarium of Peter Macpherson" from Keith Watson. Boyd Orr Building.

June 9th
Conference: *The Amphibians and Reptiles of Scotland: Current Research, Future Challenges*. Graham Kerr Building.

June 19th
Summer Social held at Oran Mor, preceded by a visit to the Filmy Ferns and Orchid Houses at Glasgow Botanic Gardens.

September 18th
Lecture: "Evolution education in Scotland, and around the world", Glasgow Natural History Society Presidential Address, from Roger Downie. Boyd Orr Building.

October 9th
Lecture 1: "Orchid bee responses to human disturbance in tropical forests" from Laura Allen. Lecture 2: "Observations on the behaviour of juvenile cuckoos 2007-2017" from Darren O'Brien. Boyd Orr Building.

November 8th
Lecture: "The adventures of three Perthshire plant hunters in the Pacific northwest : Archibald Menzies, David Douglas and John Jeffery" from Syd House, jointly with Friends of Glasgow Botanic Gardens and the Glasgow Tree Lovers' Society. Bower Building.

November 13th
Lecture 1: "Did we find the wildlife in Ayrshire?" from Helen Embleton.
Lecture 2: "Floristic biodiversity in fragmented tropical landscapes" from Emily Waddell. Boyd Orr Building.

November 28th
Blodwen Lloyd Binns Lecture: "Surviving the Anthropocene - a story of biological gains as well as losses" from Chris Thomas. Graham Kerr Building.

December 11th
Christmas buffet dinner followed by "Dead useful - what strandings can tell you about the marine environment" from Andrew Brownlow. Graham Kerr Building.

Excursions
16 day excursions, three joint excursions with the Clyde and Argyll Fungus Group and one weekend excursion were held throughout the year.

Officers and Council elected at the 2018 AGM

President
Chris McInerny

Vice Presidents
Tony Payne
Barbara Mable
Roger Downie

General Secretary
Mary Child

Assistant Secretary
Lyn Dunachie

Treasurer
Susan Futter

Winter Syllabus
Roger Downie

Excursions
Alison Moss

Membership Secretary
Richard Weddle

Librarian
Janet Palmar

***The Glasgow Naturalist* Editor**
Iain Wilkie

***The Glasgow Naturalist* Assistant Editor**
Chris McInerny

***The Glasgow Naturalist* Assistant Editor**
Ruth Maclachlan

Newsletter Editor
David Palmar

Section Convenors
Richard Weddle: Bio-recording
Alison Moss: Botany
Norman Storie: Ornithology
David Palmar: Photography
Myles O'Reilly: Zoology
Ann Ainsworth: Geology

Councillors
Bob Gray
Erik Paterson
Laura Allen

BLB Executive
Chair: Barbara Mable
Secretary: Mary Child
Treasurer: Susan Futter
Scientific Advisor: Tony Payne
Technical Advisor: Richard Weddle
Financial Advisor: Bob Gray

The Glasgow Naturalist

Information for Contributors

1. *The Glasgow Naturalist* publishes articles, short notes and book reviews. All articles are peer reviewed by a minimum of two reviewers. The subject matter of articles and short notes should concern the natural history of Scotland in all its aspects, including historical treatments of natural historians. Details of the journal can be found at: www.gnhs.org.uk/publications.html

2. Full papers should not normally exceed 20 printed pages. They should be headed by the title and author, postal and email addresses. Any references cited should be listed in alphabetical order under the heading References. All papers must contain a short abstract of up to 200 words, which should summarise the work. The text should normally be divided into sections with sub-headings such as Introduction, Methods, Results, Discussion, Acknowledgements and References.

3. Short notes should not normally exceed one page of A4 single-spaced. They should be headed by the title and author's name, postal and email address. Any references cited should be listed in alphabetical order under the heading References. There should be no other sub-headings. Any acknowledgements should be given as a sentence before the references. Short notes may cover, for example, new locations for a species, rediscoveries of old records, ringed birds recovered, occurrences known to be rare or unusual, interesting localities not usually visited by naturalists, and preliminary observations designed to stimulate more general interest.

4. References should be given in full according to the following style:

Pennie, I.D. (1951). Distribution of capercaillie in Scotland. *Scottish Naturalist* 63, 4-17.

O'Reilly, M., Nowacki, S. & Gerrie, E. (2018). New records of the white-banded grapple-worm. *The Glasgow Naturalist* 26(4), 96-97.

Wheeler, A. (1975). *Fishes of the World*. Ferndale Editions, London.

Smith, C.W., Aptroot, A., Coppins, B.J., Fletcher, A., Gilbert, O.L., James, P.W. & Wolseley, P.A. (2009). *The Lichens of Great Britain and Ireland*. (2nd edition). The British Lichen Society, London.

Grist, N.R. & Bell, E.J. (1996). Enteroviruses. In: Weatherall, D.J. (Editor). *Oxford Textbook of Medicine*, pp. 381-390. Oxford University Press, Oxford.

References with more than six authors: name the first six authors, then add "*et al.*"

5. References should be cited in the text as follows:

Single author: Pennie (1915)… (Pennie, 1915). Two authors: Grist & Bell (1996)… (Grist & Bell, 1996). More than two authors: Smith *et al.* (2009)… (Smith *et al.*, 2009). Multiple citations: (Pennie, 1915; Grist & Bell, 1996). Same author(s), publications in different years: (MacGillivray, 1840, 1855).

6. An organism's genus and species names should be given in italics when first mentioned. Thereafter only the common name is required. Please use lower case initial letters for all common names, e.g. wood avens, blackbird, unless the common name includes a normally capitalised proper name, e.g. Kemp's ridley turtle. The nomenclature of vascular plants should follow Stace, C.A. (2010). *The New Flora of the British Isles*. (3rd edition). Cambridge University Press, Cambridge. Normal rules of zoological nomenclature apply. When stating distribution, it may be appropriate to give information by vice-county.

7. All papers, including electronic versions, must be prepared on A4, double spaced throughout, with margins of 25 mm, with 12 point Times New Roman font. Tables and the legends to figures should be typed on separate pages at the end of the manuscript.

8. Tables are numbered in arabic numerals, e.g. Table 1. These should be double-spaced on separate pages with a title and short explanatory paragraph underneath.

9. Line drawings and photographs are numbered in sequence in arabic numerals, e.g. Fig. 1. If an illustration has more than one part, each should be identified as, e.g. 9A, B etc. They should be supplied as high resolution digital images either in separate files or on separate pages at the end of the manuscript: they should not be embedded in the text. A metric scale must be inserted in photomicrographs etc. Legends for illustrations should be typed on a separate page.

10. Authors should assure the Editor explicitly that all illustrations, including maps, do not infringe copyright law.

11. Articles should be submitted to the Editor: Dr Iain Wilkie by email Editor@gnhs.org.uk as a single word-processed document. Photographs and illustrations should be high resolution with a minimum of 300 dpi in tif or jpeg format. Please contact the Editor if you require assistance with photographs.

12. When the article is accepted for publication, the author should return the corrected manuscript to the Editor as soon as possible. Final proofs should be returned to the Editor by email / return of post. Alterations at this stage should be kept to the correction of typesetting errors. More extensive alterations may be charged to the author.

13. A copy of the published article will be sent to the first author as a pdf file. A paper copy of the article can be provided if requested.

14. All submissions are liable to assessment by the Editor for ethical considerations, and publication may be refused on the recommendation of the Editorial Committee.

15. Authors must sign a publishing agreement giving the GNHS copyright for articles published in *The Glasgow Naturalist*. This is standard procedure for publishing in most scientific journals, and allows the article to be archived at the Biodiversity Heritage Library https://www.biodiversitylibrary.org/bibliography/38981#/

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